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**A SMALL INTERACTIVE SCIENCE CENTRE AS A
LEARNING ENVIRONMENT FOR STUDENTS
WITH SEVERE LEARNING DIFFICULTIES:
AN EXPLORATION OF PEDAGOGY**

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BA hons

This thesis is submitted in partial fulfilment of the requirements of the Open
University (Faculty of Science) governing the award of the degree of
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ABSTRACT

This study explores the use of a small interactive science centre as a learning environment for students with severe learning difficulties and is based on extensive video footage of nine students between the ages of six and nineteen. Participants were filmed across two academic years during visits to the science centre, and in their school or college, both in their usual classes and in follow-up sessions designed by the researcher. All participants were from educational provisions designated as being for students with severe learning difficulties.

Analysis based on grounded theory strategy (Glaser and Strauss 1967, Strauss and Corbin 1998) was used to explore the complexities of a learning situation that did not appear to have been studied in this way before. Systematic coding and categorisation of video data was supplemented by semi-structured interviews with the students' teachers, using video material to stimulate recall. These interviews provided a separate viewpoint for triangulation purposes and, with the video analysis, suggested an unusually high degree of independent and focused activity on the part of the students during visits to the science centre.

Results have confirmed the very high level of engagement and independent activity remarked on by the teachers, both in the science centre and when a similar environment was created in school or college. The use of grounded theory techniques has permitted the formation of hypotheses, grounded in the data, and small-scale sequential and quantitative analysis has made it possible to further explore a number of these relating to pedagogical factors within the environment; notably input mode (whether this was language-based or multi-sensory) and the importance of choice and control. Implications for debates concerning teaching methods and learning environments and indirectly for those concerning the provision of more inclusive environments are discussed.

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CONTENTS

CHAPTER 1: INTRODUCTION	1
1.1 Rationale for the Research	1
1.2 The Study	3
1.3 The Research Setting: The Interactive Science Centre	4
1.4 Structure of the Thesis	6
CHAPTER 2: LITERATURE REVIEW	9
2.1 Epistemological Framework for the Research	9
2.1.1 Action and experience as preliminaries to understanding	10
2.1.2 Ways of learning and knowing	23
2.1.3 Play and informal learning	31
2.1.4 Socio-cultural theory and social constructivism	39
2.1.5 Flexible learning: transfer and generalisation	41
2.2 Historical and Conceptual Background to the Research Setting	42
2.2.1 Historical framework: the interactive science centre movement	43
2.2.2 Research in ISCs	44
2.2.3 Previous research in the ISC that is the setting for this study	51
2.3 Pedagogy in Special Education	53
2.3.1 The historical context: the rise of behavioural approaches	53
2.3.2 Challenges to behaviourism	55
2.3.3 Alternative approaches	59
2.3.4 The influence of the National Curriculum: vehicle for change or sidelining debate?	71
2.3.5 Integration or inclusion?	76
2.3.6 Pedagogy for SEN or for all?	79
CHAPTER 3: METHODOLOGY AND METHODS	90
3.1 Introduction	90
3.2 Rationale for the Approach	91
3.2.1 Choice of paradigm	91
3.2.2 Choice of methodology	92
3.3 Ethical Considerations	101
3.3.1 Informed consent	102
3.3.2 Anonymity	103
3.3.3 Use of photographs and video material	103
3.3.4 Ownership of data	103

3.4	Research Questions and Hypotheses Arising from the Data	104
3.4.1	Research questions relating to the descriptive/ exploratory phase	104
3.4.2	Research questions and hypotheses relating to the explanatory phase	110
3.5	The Research Design	111
3.5.1	Summary of the design	111
3.5.2	The research design: descriptive/exploratory phase	114
3.5.3	The research design: explanatory phase	117
3.5.4	Selection of participants	118
3.5.5	Data collection	119
3.5.6	Data analysis	122
3.6	Reliability and Validity	126
3.6.1	Reliability	126
3.6.2	Threats to validity	131
3.7	Generalisability	133
CHAPTER 4: FINDINGS		137
4.1	Preliminary Studies	137
4.1.1	Preliminary study 1	137
4.1.2	Preliminary study 2: video-recorded sessions	142
4.2	Pen-portraits and Description of ISC, Follow-up and School/College Sessions for All Participants	146
4.2.1	Alan	148
4.2.2	Gemma	174
4.2.3	Karen	192
4.2.4	Bill	208
4.2.5	Michael	219
4.2.6	Richard	229
4.2.7	Jackie	237
4.2.8	Louise	243
4.2.9	Alex	246
4.3	Semi-Structured Interviews with the Participants' Teachers	250
4.3.1	The teachers' views on the students' responses and on teaching approaches	250
4.3.2	The teachers' views on the typicality or otherwise of the students' responses in the different sessions	259
4.4	Findings Relating to Sequential Analysis	261
4.4.1	Sequential analysis of events preceding sequences coded as 'investigation or exploration'	261
4.4.2	Sequential analysis designed to explore the effect of interactions with other people on students' engagement with activities	268
4.5	Summary of Findings	281
4.5.1	Bar graphs showing proportion of time spent in different types of engagement	281

4.5.2	Summary of findings in relation to the research questions posed in the descriptive/exploratory phase of the research	292
CHAPTER 5: DISCUSSION		311
5.1	Evolving Hypotheses	311
5.1.1	Exploration of the hypotheses in relation to the findings and to the literature	314
5.2	Alternative Explanations	319
5.3	Issues Relating to the Research Design and to Methodology	321
5.3.1	Risks to validity	321
5.3.2	Generalisation	322
5.4	Implications for Practice	324
5.5	Implications for Future Research	327
CHAPTER 6: CONCLUSION		330
BIBLIOGRAPHY		336
TABLE OF APPENDICES		
Appendix I	Activities at the science centre	361
Appendix II	Coding systems	371
Appendix III	Sample of video transcript showing open coding	373
Appendix IV	Sample of video transcript showing theoretical coding	374
Appendix V	Colour-coded charts 1: visual summaries for all sessions for five main participants	375
Appendix VI	Colour-coded charts 2: Charts showing sequential analysis for ISC visits for five main participants	384
Appendix VII	Sample of field notes	402
Appendix VIII	Published work associated with this thesis	403

CHAPTER 1: INTRODUCTION

1.1 Rationale for the Research

I was responsible for the day to day running of the interactive science centre (ISC) that was the setting for the research on a part-time basis for a period of five years. The ISC was a joint school/university venture, designed as a setting for educational research as well as a venue for school visits and I was involved in a number of research projects in my capacity as research assistant (Brooke and Solomon 1996, 1998) as well as carrying out my own project (Brooke 1994). I have also worked for nine years with students with learning difficulties, responsible for a small provision for pupils with severe language and communication difficulties on a mainstream school site, with high levels of inclusion, and providing advice and support to mainstream schools around the county.

Our previous research (Brooke and Solomon 1996, 1998, Brooke 1994) carried out in the ISC had examined the relationship between play and learning for pupils in mainstream classes, showing how these pupils moved spontaneously from play to exploration. Interview techniques had been used to gauge students' recall of visits and ability to use what they remembered to solve hypothetical problems. This research had also, incidentally, shown the centre to be a very effective learning environment for pupils with moderate learning difficulties (MLD) in mainstream classes in that they were frequently indistinguishable from their peers, both when working in the centre and when interviewed afterwards about what they had done and found out there. These pupils were not the main focus of these studies so it is only possible to speculate about why this was so: those with learning difficulties in mainstream educational settings

often experience repeated failure leading to low self-esteem and to behaviour problems or to learned helplessness and passivity (Locke 1996, Watson 1996). It is probable that the visit out of school was a motivating factor for these pupils but it seems likely that the playful, task-free nature of the activities also played a significant role; Sylva, Bruner and Genova (1976, p.24) wrote of play as '*a moratorium on frustration*,' a situation where there is no fear of failure because there is no externally imposed goal.

If this was true for students with MLD it seemed possible that it would be even more so for those with severe learning difficulties (SLD)¹. Griffiths (1994) has suggested that frequent experience of failure in a puzzling 'real' world may be a factor in the passivity of young people with SLD. Others (e.g. Wood and Shears 1986, Byers 1994) have suggested conversely that teaching methods in which learning is broken down into small adult-directed steps, and failure largely eliminated, can also contribute to passivity. The occasional visit from students with SLD to the science centre had suggested that in this environment they could be far from passive and comments from their teachers suggested that their behaviour in this setting was often strikingly different to behaviour in the school setting.

The aim of this study was to explore the possibilities of this setting for a small group of students with SLD; the focus was on pedagogical issues, the effect of a particular learning environment on learning behaviour for a particular group, the learning process

¹ The terms 'with severe learning difficulties' and 'with moderate learning difficulties' are used for the sake of brevity to indicate groups of pupils categorised in this way within the education system. I recognise that such terminology can cause unintentional offence and stress that the participants were considered first and foremost as individuals rather than as a homogeneous group.

rather than the product. Murphy (1996, p.11) has pointed out 'the unique, interactive nature of pedagogy'; this view of pedagogy, as being about the '*interactions between teachers, students and the learning environment and learning tasks*' (p.17) is central to this research. Such a study has the potential to make a contribution to a number of important debates in both special and mainstream education, notably those surrounding teaching methods and learning environments. The debate concerning inclusion is, to some extent, a related issue: a major factor in promoting inclusive education is likely to be the creation of environments and the use of methods that do not in themselves disadvantage some learners from the outset.

1.2 The Study

An initial literature search had not revealed any studies of visits to ISCs by students with SLD, and analysis based on grounded theory strategy (Glaser and Strauss 1967, Strauss and Corbin 1998) was chosen to explore the complexities of a learning situation that did not appear to have been studied in this way before. In accordance with grounded theory principles the aim was to explore the situation with as few preconceptions as possible but with, nevertheless, a 'theoretical sensitivity' (Glaser and Strauss 1967) derived from previous research in the ISC and literature relating to this.

The research approach also shared many features with case study; the case being the responses of nine students to a particular learning situation. This was initially descriptive or exploratory in character, moving into an explanatory phase. I went beyond the usual parameters of a case study, however, in that, as the researcher, I created a number of situations (follow-up visits) in order to answer specific questions

that arose from the data (theoretical sampling in grounded theory terms (Glaser and Strauss 1967, Strauss and Corbin 1998)).

1.3 The Research Setting: The Interactive Science Centre

The interactive science centre (ISC) which was the setting for the present research was by no means typical of the ISCs that sprang up in the UK in the 1980s and 90s, but its very atypicality made it an ideal setting for the study. It was not normally open to the general public and consisted only of one large room, roughly eight metres by nine, in a junior school; its small size meant that it could accommodate only one group at a time. For students with learning difficulties this meant a calm and secure setting in which they could move around at will; large public science centres had found that groups of pupils with learning difficulties were often distracted and intimidated by high numbers of other visitors (personal communication).

The activities at the ISC were all based around a National Curriculum (NC) theme, changed each summer, and were designed to allow open-ended investigation. Gregory (1986) described three generations of museum exhibit: traditional 'hands-off' exhibits; those in which something happens when a button is pressed; and a third generation in which there is real 'hands-on' activity, for example a 'wind tunnel' with two different shapes of car to try out. Solomon (Brooke and Solomon 1996) has described the activities at this ISC as belonging to a fourth generation in which the visitor takes part in the design of the investigation as well as its performance. Here the 'wind tunnel' not only had different shapes and sizes of cars to try out but also card and sellotape so that pupils could alter the shape of the chassis. The open-ended design of activities made it a particularly suitable

setting for research into independent play and learning as visitors had more choice and control over activities than at most ISCs.

Activities during the period of the preliminary studies related to Energy and Electricity, and included a water-lift, a wind generator, a model house with computer-linked temperature probes and a variety of different types of circuit. During the main data collection phase of the research activities related to Forces and Movement and included the 'wind tunnel', a tank of live goldfish with magnifying lenses to help with observing movement, a life-size model of a human skeleton riding a bicycle and a solenoid or electro-magnetic coil (see Appendix I for full details and illustrations).

Visits from groups of students with SLD typically lasted around an hour, although this was left to the discretion of the teacher. Sessions started with a brief demonstration of some of the possibilities of the equipment, after which pupils were left free to make their own choice of activity. They generally finished, as for mainstream groups, with a 'scientists' conference' where pupils were asked what they had done and enjoyed and, where possible, about anything they had found out. Some students used demonstration to show this where they lacked language to talk about it.

The role of the researcher within the setting

My usual role in the ISC was that of organiser and facilitator of visits, so, as the researcher, I had a dual role. Cohen, Manion and Morrison (2000) distinguish between participant and non-participant observation, insider and outsider research; in fact my role fell somewhere between the two in both cases. I was a participant to some extent, carrying out my usual

role in the ISC of introducing the activities and of helping when needed, however, as for mainstream groups, I deliberately stood back as far as possible to allow the students the freedom to do what they wanted to do and this left me some opportunity to observe. Nevertheless, it would not have been possible to observe an entire session while carrying out my usual role and this was one of the reasons for the decision to use video cameras to gather data in the main phase of the research. The fact that I was not the camera-operator left me available to help the students if they wanted help as well as ensuring that, as the researcher, I was not selectively filming episodes to fit any pre-conceived ideas (see Chapter 3). I was also both insider and outsider: a part of the visit with a role beyond that of observer but a stranger to the students and visiting staff.

1.4 Structure of the Thesis

Following this introductory chapter the thesis presents a literature review. In accordance with grounded theory principles (Glaser and Strauss 1967, Strauss and Corbin 1998), previous research in the ISC and the literature that had contributed to it provided a background of ‘theoretical sensitivity’ to this study, informing the initial broad, exploratory question: ‘How do students with severe learning difficulties respond to visits to a small interactive science centre?’ An ongoing literature review then progressively informed the research as it unfolded and further questions and hypotheses were formulated. The body of literature thus accumulated is presented in sections beginning with the epistemological framework for the research: theories of learning that proved important for the understanding of the research setting and of the students’ usual educational setting as well as for analysis of findings. This is followed by an analysis of the historical and theoretical background of the research setting (the ISC) and lastly the historical and pedagogical

background of the students' usual educational settings including the pedagogical debates surrounding special and inclusive education to which it is hoped the research has a contribution to make.

The third chapter sets out the methodology, beginning with the initial research question which was the starting point for the study and the rationale for the choice of methodology. Research questions and hypotheses grounded in the data that arose as the research progressed, as part of the cyclical, grounded theory, process, are set out together here for clarity. These are followed by a description of the way in which the design relates to grounded theory cycles and of the two phases of the research design – descriptive/exploratory and explanatory - that were evolved to address emerging questions and theories. Ethical questions, particularly important in working with people with learning difficulties, are discussed with the measures taken to ensure that the research met stringent ethical criteria. All procedures relating to selection of participants, data collection and data analysis are set out in full in order to provide an 'audit trail' (e.g. Robson 1993). Risks to reliability and validity and the safeguards put in place to minimise these as well as issues of generalisability are discussed.

The findings are presented in chapter four, beginning with data from the preliminary studies, followed by detailed, rich, descriptions of all sessions at the ISC and the students' usual educational settings for the five major participants. Somewhat more condensed descriptions of all sessions are presented for the remaining four students. Salient features relating to all research questions and hypotheses are highlighted in the accompanying narrative. Semi-structured interviews were undertaken with the participants' teachers using video sequences to stimulate recall and these are summarised here. Colour-coding of

behaviour sequences relating to level and type of engagement with activities made it possible to display these along a timeline, to build up visual summaries of sessions and to use the data for small-scale sequential analysis also presented here. The last section of this chapter presents a visual summary of findings in the form of bar-graphs showing the proportion of time spent in different levels and types of engagement for different parts of each session for each of the five main participants. It finishes with a summary of the findings in relation to each of the questions posed.

The following discussion chapter draws the threads of the thesis together. Following a review of the extent to which it has been possible to answer the questions that arose during the first (descriptive) phase the second section examines the hypotheses that were the starting point for the explanatory phase, how these evolved and how far it was possible to verify them against the data and against the literature. Possible alternative explanations and other issues relating to methodology are discussed. The chapter culminates in a discussion of the implications of the study for practice and for future research. The thesis ends with a short concluding chapter which restates the aims of the research, summarises the main findings and outcomes and draws conclusions.

CHAPTER 2: LITERATURE REVIEW

In accordance with the principles of grounded theory (Glaser and Strauss 1967, Strauss and Corbin 1998) the literature informed the research progressively: contributing initially to a starting point of ‘theoretical sensitivity’, the awareness of what had gone before, then, as the work progressed, informing questions that arose or hypotheses that were formulated.

The literature review is comprised of three interwoven strands:

- The epistemological framework: theories of learning and knowing underpinning the research design and ongoing analysis.
- The historical and theoretical context of the research setting: ideas underpinning the conception of ISCs in general and the particular ISC in which the research took place, previous research in these settings.
- The historical and theoretical context of the participants’ usual educational environment, debates concerning pedagogy in special education.

2.1 Epistemological Framework for the Research

This section explores theories about learning and knowing that informed the research design as well as ongoing hypotheses and decisions about analysis as the research unfolded. Many of these bodies of literature were influential in the ISC movement or in developments in special education, and a significant number were influential in both areas.

2.1.1 Action and experience as preliminaries to understanding

The term 'interactive' has two frequently related but rather different connotations:

interaction with the environment and interaction with others. The latter meaning assumed increasing importance for this research as it progressed, as will be explored later, but in interactive science centres the term originally emphasised interactions with the environment, and such interactions as a basis for understanding of the world.

Fundamental, then, to the original conception of ISCs (and to the original conception of this research) was a view of action as an important preliminary to understanding. This section - necessarily very briefly - traces the history of these ideas.

The idea that learning takes place through interaction with the natural environment belongs to a tradition that can be traced back at least as far as Aristotle (384-322 BC). Experience as the basis for our knowledge and understanding of the world may appear intuitive and yet, in this, Aristotle himself departed from the Platonic idealism that separated the world of forms or ideas from the world as apprehended by the senses. The extent to which experience, and the evidence of the senses, can, or cannot, form a reliable basis for knowledge of the world has been a recurring theme in philosophy and epistemology (see for example Bagгинi and Stangroom 2004).

Disagreements about the primacy of experience or of reason opposed the movements that became known as empiricism and rationalism in 17th and 18th century Europe.

Empiricism, based on the firm belief that learning should be derived from observation and experiment, flourished particularly in Great Britain but was not confined to it.

Comenius (1592-1670), an early educational theorist and a contemporary and admirer of

Bacon (1561-1626) and his New Atlantis 'where all of science would be discovered and verified by open experiment', held that learning should begin with the senses and has been described as an early advocate of learning through doing (Solomon 2003). Locke (1632-1704), a leading proponent of empiricism, maintained that all learning was derived from experience, even if his refusal to trust children to learn naturally infuriated Rousseau (Smith 2001). Interestingly, the two terms experiment and experience were virtually synonymous at this time in English as they remain in French. Locke's views would now seem extreme in their support of the nurture side of the nature/nurture debate; Locke famously described the child as a *tabula rasa* on which experience writes: '... of all the men we meet with, Nine parts out of Ten are what they are, Good or Evil, useful or not, by their Education' (cited in Smith 2001, p.45). The tenth part he did nevertheless ascribe to 'original temper' or character (Smith 2001).

In contrast, in 17th century France, rationalism and the mind/body dichotomy of Descartes' famous '*cogito ergo sum*', I think therefore I am, held sway; reason was paramount, the senses mistrusted. It is, of course, a simplification to see the relative positions of rationalists and empiricists as entirely clear cut, nevertheless Rousseau (1712-78) presented a somewhat lonely figure in 18th century France with his insistence that learning should take place through the senses. The legacy of this mind/body dualism in educational theory will be further explored in Section 2.1.2.

Kant (1724-1804) in the late 18th century did not subscribe entirely to either the rationalist or empiricist viewpoint but 'occupied a more difficult to locate middle ground' (Baggini and Stangroom 2004, p.8). He held with the rationalists that the mind gives

form to experience, but followed the empiricists in arguing that the only world we can know is the one given to us by experience. The world in itself, for Kant, is unknowable; our view of the world is shaped by our ability to perceive it. These ideas were developed by the phenomenologists, who looked to human consciousness as the only thing of which we have certain knowledge. Husserl (1859 – 1938) considered the founder of phenomenology, attempted to divest the phenomena of everyday experience of their cultural and symbolic structures in order to ‘place the world in brackets and get back to the things’ and to the fundamentals of human consciousness (see for example Duhan Kaplan 2004).

Merleau-Ponty (1908-1961) further developed phenomenological theory; rejecting the idea of Cartesian dualism, he proposed the idea of ‘the lived body’, as intermediary between the subjective and objective world, seeing perception as key, not sensory stimuli alone but the organism as a whole, including bodily senses and memory (Paterson 2004). Varela, Thompson and Rosch (1993) drew on phenomenology and in particular on Merleau-Ponty’s ideas to postulate a view of cognition that is not merely based on perception but is inseparable from it: the ‘embodied mind’:

We propose as a name the term enactive to emphasize the growing conviction that cognition is not the representation of a pregiven world by a pregiven mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs.
(Varela *et al* 1993, p.9)

Varela *et al* (1993) explored the idea that there is no absolute reality independent of the observer, using colour perception to illustrate this counter-intuitive proposition. How colour is perceived depends on biological receptors but also on cultural and linguistic factors, it is neither ‘out there,’ independent of perception and cognition, nor ‘in here,’

independent of biological and cultural world; 'color as a case study enables us to appreciate the point that ... world and perceiver specify each other' (Varela *et al* 1993 p172). These ideas have resonances from the work of Piaget and of Dewey discussed later. The idea that we enact our learning is clearly an important one for interactive learning in the sense of interaction with the environment; whether or not we trust our senses they are our way of knowing the world. Ideas relating to phenomenology, to perception and illusion, were of particular interest to the creators of the early interactive science centres (see below, Section 2.2).

Pragmatism and the educational theory of John Dewey (1859-1952)

Both rationalist and empiricist epistemologies regarded knowledge as based on some unshakeable foundation, the argument centring around whether this could be apprehended through human experience or human reason. This foundationalist standpoint was increasingly called into question, culminating in the 20th century in the work of Popper (1902-1994) and those like him who held that nothing can be known with absolute certainty and all scientific ideas are 'true' only until falsified. The pragmatists, including Dewey (1859-1952), on the other hand, circumvented the question, believing that it was futile to worry about whether or not knowledge can be certain and that 'crudely put what is true is what works' (Baggini and Stangroom 2004, p.3).

Dewey accorded experience a central role in education, maintaining that education should start from students' lived experience and interests. This was not a passive process; learning for Dewey was 'a continuing reconstruction of experience' in which the learner both acts on the environment and is acted upon by it:

When we experience something we act upon it we do something with it; then we suffer or undergo the consequences. We do something to the thing and then it does something to us in return. (Dewey 1916, p.163)

This view of ‘enactive’ learning finds an echo in the work of Piaget and of Varela *et al* (1993) discussed later. However, as Apple and Teitelbaum (2001) noted, Dewey’s ideas had little influence in the classroom at the time, in part, at least, because of the increasing dominance of behaviourist ideas in psychology and education at that time in the English-speaking world and especially the USA.

Behaviourism and learning theory

The logical positivists, starting with Comte (1798 – 1857), sought a ‘scientifically based philosophy that would be free of all speculation and anchored firmly in positive knowledge’ (Lawhead 2004, p.68), and strongly influenced scientific thinking, psychology and educational theory in the first half of the twentieth century, particularly in the USA. Varela *et al* (1993, p.45) described behaviourist psychology as ‘particularly compatible with the early 20th century positivist zeitgeist of disembodied objectivism in science’ in which only the observable and measurable were seen as legitimate objects of scientific study: inputs (stimuli) and responses (behaviour) and the relationships between these, but not what went on in the ‘black box’ of the mind. The predominance of behaviourist theory in North America throughout the first half of the twentieth century influenced a shift away from ideas about active learning through experience of Dewey and others. The environment retained a central role but as the source of stimuli, inducing responses in a passive subject.

Learning theory, derived by B.F. Skinner (1904–1990) from behaviourist psychology, emphasised positive reinforcement and an optimistic view of learning, suggesting that given the right teaching all children were educable, and that shortcomings derived from teaching methods rather than the child; a view that made it particularly appealing to special educators in the 1970s (see Section 2.3). Yet Holt (1990) in the early 1960s described an education system in the USA based more on negative reinforcement, on the use of ridicule and even fear. Holt's work was both symptomatic of, and influential in, a shift in thinking in mainstream education at that time, a shift influenced by a reaction in the late 1950s and 1960s against behaviourism and a renewed interest in cognitive psychology.

The dominance of behaviourism was being challenged at a number of levels from the late 1950s: Varela *et al* (1993, pp. 45-6) noted how work on mental images and information processing models of cognition challenged the notion that what went on in the mind was not worthy of scientific study and the work of Chomsky (b.1928) suggested that a behaviourist model of language acquisition was no longer tenable. However, one of the greatest influences on educational thought came from the increasing interest in the USA and UK of the 1960s in a view of the child as actively constructing knowledge through interaction with the environment; a view that drew not so much on the work of Dewey or his predecessors but extensively, and some would say selectively (Van der Veer and Valsiner 1994), on the constructivist epistemology of Piaget (1896–1980) only then becoming known in the Anglo-American world. Piaget himself, working in a European context was influenced less by behaviourism and more by Darwin and by Freud (Piaget's

méthode clinique derived initially from then current psychotherapy/ psychoanalytic techniques – Dolle 1974, pp.20-21).

The constructivist epistemology of Jean Piaget (1896-1980)

The work of Piaget was influential in special, as well as mainstream, education in the 1960s, and again in special education in the 1980s when special educators began to question the behaviourally-based methods that had come to dominate their field. The degree of influence that Piaget's ideas have exerted in both mainstream and special education - although Piaget himself was not an educationalist and could indeed be scathing about the role of educators in child development - make consideration of these important for this study, despite the fact that they have now been challenged from many quarters, as is explored below.

Interaction between the developing organism and the environment formed the cornerstone of Piaget's epistemological theory :

From the beginning I was convinced that the question of the relationship between organism and environment could also be posed in the realm of knowledge; in this case it was the question of the relationship between the acting and thinking subject and the objects of his experience.¹
(Piaget 1966, p.137. My translation)

Piaget was by training a biologist and the two main processes by which he saw development as taking place were derived from biology: 'assimilation', the way in which

¹ *Dès le début, j'étais convaincu que le problème des relations entre organisme et milieu se posait aussi dans le domaine de la connaissance, apparaissant alors comme le problème des relations entre le sujet agissant et pensant et les objets de son expérience.* (Piaget 1966, p.137)

the body assimilates something from the environment - food or ideas - into existing structures and 'accommodation', the adaptation of the organism (whether the lens of the eye or mental 'schemata') to fit new information from the outside world. Through these two processes, Piaget postulated, the child's intelligence develops as it explores the world:

By incorporating new elements within existing schemata, the developing intelligence constantly modifies the latter by adding new information. On the other hand, nothing can be known of itself since this accommodation is never possible except in relation to its opposite, assimilation. It is in adapting to things that thought organises itself and it is in organising itself that it structures the things.² (Piaget 1963, p.12-13. My translation)

Like Dewey (1916), Piaget saw the developing intelligence as both structured by and structuring its environment, in the words of Varela *et al* (1993) 'enacting' its learning.

Challenges to Piaget and Neo-Piagetians

Varela *et al* (1993) described Piaget as a giant in the field of enactive learning and yet it is in the nature of such giants that others will stand on their shoulders in order to develop, or react against, their theories. It may be that Piaget's attempt to find an all-embracing, biologically-based, model for mental development has made it something of a Procrustean bed (observation at times appearing to be made to fit the theory rather than the reverse) and as such particularly vulnerable to challenge. The Piagetian model has been challenged both in its detail - for example the ages at which the different stages are reached - and at a more fundamental level. However, much of this recent work has

² *En incorporant les éléments nouveaux dans les schèmes antérieurs, l'intelligence modifie sans cesse ces derniers pour les ajouter aux nouvelles données. Mais inversement les choses ne sont jamais connues en elles-mêmes, puisque ce travail d'accommodation n'est jamais possible qu'en fonction du processus inverse d'assimilation. C'est en s'adaptant aux choses que la pensée s'organise elle-même et c'est en s'organisant elle-même qu'elle structure les choses.* (Piaget 1963, p.12-13)

developed from, or been a direct reaction to, Piaget's ideas. Some of this work is considered in this section, particularly with regard to the role accorded to interaction, both with the environment and with others.

Constructivism as a basis for educational practice

Piaget rejected a view of himself as an educationalist and Walkerdine (1989, p.200) has pointed out that 'there neither is, nor ever has been, a Piagetian pedagogy' and, yet Piaget's ideas have had a significant influence on educational theory and practice. More extreme experiments in discovery learning in the 1960s, particularly in the USA, relegated the role of teacher to merely providing a suitable environment in which the child would learn naturally once they had reached the appropriate stage. These were for the most part rapidly abandoned and evaluations suggested that reported successes had often been due to their novelty, the 'Hawthorn Effect' (see Solomon 1994). Walkerdine (1989) noted the inherent contradiction between a child-centred pedagogy which stressed individual freedom and the set of practices and apparatuses aimed at assessing and normalizing children's behaviours in terms of Piagetian stages, so that 'observation and monitoring of child development became a pedagogy in its own right' (p.198).

In science education, approaches based on constructivist theory gained popularity during the 1980s; these were based on the theory that by getting children to discuss their pre-conceptions about phenomena in the physical world they could be guided towards a more 'scientific' understanding. However, as Solomon (1994, 1995) pointed out, the children's original ideas proved remarkably resistant to change and could even become more entrenched through discussion.

Nevertheless, a view of the learner as actively constructing understanding through interactions and experiences, of 'action and self-directed problem-solving at the heart of learning and development' (Wood 1998 p.5) is an enduring one, now increasingly tempered with the recognition of the importance of socio-cultural factors. Both elements have been influential in recent research in interactive science centres and in the present study.

The role of language in Piagetian tasks

Language has played a crucial role in debates concerning Piagetian theory at a number of levels. Piaget claimed to study children's responses independently of language, which he considered peripheral (Dolle 1974), yet Donaldson (1987) showed that children were failing Piagetian tasks because of the language in which they were couched, or because the nature of the tasks was outside their experience, rather than because they did not understand the concepts involved. Donaldson and her co-workers (Donaldson 1987) also demonstrated that children were not as ego-centric as Piaget had claimed, or at least that they were able to 'de-centre' at a much younger age, if language and tasks were suitably adapted. Debates concerning the Piagetian model of language acquisition and of the role of language in development are explored later.

Constructivism or nativism? Domain-general or domain-specific learning?

Piaget's theories were further challenged at the more basic levels of the extent to which knowledge is innate or constructed and whether it is a domain-general process, as Piaget hypothesized, or one which is encapsulated in separate domains. The importance for this study again lies in the role accorded to experience in these theories. Piaget saw

development as proceeding - from a base in which very little was held to be innate - by a process of constant re-equilibration across all domains of learning more or less simultaneously. In his later writings he acknowledged the problematic nature of the existence of periods where a particular stage appears to be reached more quickly in some domains than others (for example the conservation of number but not of mass) and attempted to rationalise it through the concept of *décalages* (discontinuities).

Chomsky, working in the 1950s and 60s, postulated an innate sensitivity to language and to grammatical rules and a specific language device to explain the way in which children acquire language. This represented a challenge to both the behaviourist model, in which language acquisition takes place through imitation and reinforcement, and to Piaget, who saw language as a feature of general intellectual development, taking place through interaction with the environment, of which other people are merely a part. Chomsky's proposition fitted with an increasing interest in cognitive science and an information-processing model of cognition, which hypothesized an innately specified modular mind (e.g. Fodor 1983). In this model, each genetically specified, independently functioning 'module' or input system, in turn outputs data in a common format for central, domain-general processing. The modules themselves are held to be 'informationally encapsulated,' inaccessible to the conscious mind (Karmiloff-Smith 1996). It is difficult to escape the feeling that this is a new 'black box'.

Varela *et al* (1993) noted that cognitive science had moved on by the 1990s, new ideas about connectionism taking more account of development through the creation of neural connections; they nevertheless suggested that artificial intelligence still had a long way to

go before it would be able to produce a computer that had the flexibility take into account the common-sense knowledge or background know-how that we use to deal with the variables of an everyday situation. McConkey (1981) and Smith, Moore and Phillips (1982) in their critiques of behavioural methods in special education (see Section 2.3) suggest that 'playing about' may be one of the keys to flexibility in learning: computers do not play!

Karmiloff-Smith (1996) proposed a synthesis between the extreme viewpoints of the constructivists and the nativists, between a view of simultaneous domain-general development and pre-determined 'hard-wired' modules. She allowed for more innate *tendencies* than Piaget (Karmiloff-Smith 1996, p.1), citing work with new-born or very young infants, that suggested that not only does the new-born human have an inbuilt sensitivity to language but a very early awareness of the rules that govern the world around them, rules of physics and of number, showing increased interest when these are violated. Development and experience retain a central role, however, in what she termed a phased rather than a staged model, hypothesizing that 'nature specifies initial biases or predispositions that channel attention to relevant environmental inputs which in turn affect subsequent brain development' (Karmiloff-Smith 1996, p.5). In other words a 'fairly limited amount of innately specified domain-specific predispositions' but with development going 'beyond modularity' (p.4). She suggested that the individual refines their understanding by a process that she called 'representational redescription' (p.17), moving from implicit knowledge or understanding, rooted in 'behavioural mastery' to varying levels of explicit understanding. This, she maintained, takes place in different cognitive and linguistic domains at different rates and continues throughout life as

knowledge is acquired in new areas. Thus Karmiloff-Smith retained a view of the learner as an active participant in the construction of his or her own knowledge, whether through interactions with the environment, with others, or a combination of the two.

Like those of Piaget, Karmiloff-Smith's theories have been criticised in their detail, and it may be that 'representational redescription' also has a reductionist tendency in its attempt to explain the complexities of cognitive development through a single mechanism. Peters *et al* (1999) repeated an experiment carried out by Karmiloff-Smith and Inhelder (1974), in which children aged between five and seven and a half were asked to balance symmetrical and asymmetrical bars on a fulcrum. They found (Peters *et al* 1999) that by using structured tuition based on Rogoff's (1990) guided participation they could help the children towards Karmiloff-Smith's final level of representation ('explicit 3: verbal report') but that intermediate stages were more complex and varied than envisaged in Karmiloff-Smith's model. They did not challenge Karmiloff-Smith's basic model, but suggested rather a need for a more elaborate version of 'representational redescription', in particular the incorporation of a social constructivist perspective.

Karmiloff-Smith (1996), then, retained a view of action as a basis for understanding but suggested that we do not leave certain ways of learning behind once a particular stage of development has been reached, rather that we return to an earlier phase each time a new area of learning is encountered. Solomon (1980) has pointed out the need to 'feel' a scientific concept as well as to articulate it; for example to place a hand inside a plastic bag in a bucket of water in order to feel the pressure. It seems likely that it is easier to understand a concept intellectually if it has first been understood with the body.

2.1.2 Ways of learning and knowing

The previous section has - very briefly – traced the history of ideas about the role of action or experience in learning. This section examines theories concerning modes of learning and of representing what is learnt; the extent to which learning can take place and be represented, non-verbally was particularly important for this research as the participants had only limited language.

Karmiloff-Smith (1966) retained a notion of hierarchy in learning; hers was not a Piagetian view of an overall progression towards formal logic, but nevertheless a movement from implicit to explicit knowledge in each domain. Bruner (1968) described movement from enactive representation, to iconic and finally to abstract symbolic representation; ideas which Hodgkin (1985) developed, adding interpersonal and musical to Bruner's modes of representation. However, neither Bruner nor Hodgkin viewed this as a linear progression, rather as something more fluid which lies at the heart of the learning – and teaching - process as 'the learner shifts from bodily movements to picture-making, to story-telling and questioning and back again' when learning anything new (Hodgkin 1985, p.7). For Hodgkin, the skill of the teacher lies in choosing the appropriate activities or materials to support this process, but also in creating space for exploration. He envisaged the learning process as taking place in what he termed 'potential space' or 'room to be and to become', in which the learner is free to move between practice, the consolidation of skills, at one end and exploration at the frontier of his or her knowledge at the other (Hodgkin 1985, p.46); the pivotal role of play in Hodgkin's model will be discussed later. The concept of 'room to be and to become' proved to be an important one for the present research; in a very concrete sense the science centre provided a safe

setting where the students were free to play or to explore, to make real choices about what to do and when and how to do it.

Hodgkin (1985, p.118) viewed the different modes of representation described above as forming ‘an open, interlocking hierarchy’, while deploring the ‘pervasive snobbishness’ that assumes that there is some special virtue in abstract thinking. Rather, he asserted, the most creative people are those ‘who can move readily from model building, to picture making, to turning an idea into mathematics or language and then back again into new models or experiments’ (p.34). Gardner (1983) in proposing a theory of multiple ‘intelligences’ - musical and mathematical, inter- and intra-personal, as well as visual and verbal – deliberately avoided a hierarchical view of these aptitudes. He suggested that some are naturally stronger than others in any given individual but that they can nevertheless be developed and strength in one used to support weakness in another (for example spatial strengths used to support mathematical difficulties). Gardner’s choice of the rather controversial term ‘intelligence’ was a deliberate attempt to counteract the notion of ‘intelligence testing’ which he saw as testing only the narrowest range of intelligences, mainly logico-mathematical. This notion of intelligence, he suggested, reflects a cultural hierarchy, which in the West values logico-mathematical intelligence above others; in other cultures the ability to navigate or to create complex musical or dance forms may be more highly prized.

Can language be by-passed?

Polanyi (1958) described different ways of knowing that reinforce and complement each other; on the one hand in-dwelling or tacit knowledge, derived from action – the kind of

body-learning that it is often impossible to put into words – on the other articulate knowledge. A similar distinction is made in dividing long-term memory into procedural and declarative (episodic and semantic) (Tulving 1972), the former being concerned with knowledge *how* or ‘skill’ memory, the latter with knowledge *that* or ‘fact’ memory. It is beyond the scope of this thesis to enter into the detail of the debate concerning the relation between these and the possible role of language in passing from one to the other or as a basis for abstract thought or concept formation; nevertheless, a brief consideration of these matters is important since language was a difficult medium for all the participants in the study. The extent to which the activities in the science centre bypassed language, or emphasised input through senses other than the auditory, may have been a significant factor in the students’ responses to them.

Vygotsky (1986) took issue with Piaget on the subject of language – in particular the language that accompanies young children’s actions and especially their problem-solving. Piaget saw this simply as a manifestation of the child’s egocentricity, the inability to ‘de-centre’:

The child talks to himself as though he were thinking aloud. He does not address anyone... This talk is egocentric, partly because the child speaks only about himself, but chiefly because he does not attempt to place himself at the point of view of his hearer. (Piaget 1959, p.9)

For Vygotsky (1978) this ‘egocentric’ speech was one forerunner of ‘inner speech’ or verbal thought. He observed that it increased if the child was experiencing difficulty in solving a problem, and, with Luria, saw it as ‘an inalienable and internally necessary part of the operation, its role being as important as that of action in the attaining of a goal’ (Vygotsky and Luria 1994, p.109). Vygotsky considered socialized speech to be even

more significant as a problem-solving tool when at a somewhat later stage this too, he hypothesized, becomes internalized and this speech ‘(which has previously been used to address an adult) *is turned inward*. Instead of appealing to an adult, children appeal to themselves’ (Vygotsky 1978, p.27) (original emphasis).

Vygotsky recognised non-verbal as well as verbal thought, however, the former originating in the internalisation of actions in the same way as he envisaged the latter deriving from speech: ‘there is a vast area of thought that has no direct relation to speech. The thinking manifested in tools belongs in this area, as does practical intellect in general’ (Vygotsky 1986, p.88). He saw the two types of thought as developing separately and, to some extent, operating independently but viewed their combination as the major step that sets human beings apart from other animals:

Although practical intelligence and sign use can operate independently of each other in young children, the dialectical unity of these systems in the human adult is the very essence of complex human behaviour. (Vygotsky, 1978 p.24)

Vygotsky (1994) and others (e.g. Bruner 1986) have stressed the importance of language as a cultural tool and, at first glance, it appears self-evident that language would be necessary in order to reflect on, discuss, and transmit complex ideas. And yet it is increasingly recognised that, for some people, images can be the more powerful cognitive tools. Einstein famously thought in pictures; Jansons (1988, p.502) described how he developed a capacity for abstract thought using the manipulation of mental models, for example manipulating ‘a resistor network by mentally cutting, folding and reconnecting it’. Peters *et al* (1999), in the study described above, used verbal scaffolding to help children understand the laws of torque, talking them through a series of attempts at

balancing symmetrical and asymmetrical beams on a fulcrum. It is tempting to wonder whether this stage could have been by-passed if the children had had experience of an old-fashioned see-saw. Clearly language is a powerful adjunct to other ways of knowing and of transmitting knowledge but it is not the only one.

Mental images and mental models

Interest in mental images in the 1950s - the discovery that these were manipulated in real time - provided a means of studying the contents of the behaviourist 'black box' (Varela *et al* 1993). The term 'mental model' has been used to mean anything from very concrete mental images of objects themselves, to explanatory analogies, or the complex diagrams or flow-charts of cognitive psychology, designed to capture the way a particular problem may be represented in the brain. To understand the world and the things (and people) in it, for it to be a reasonably predictable place, we need to have some kind of internal model – concrete or abstract – of the way things 'work'. These models 'need not be technically accurate (and usually are not) but they must be functional' (Gentner and Stevens 1983, p.7). For some people an analogy may be very helpful to understanding natural phenomena; Gentner and Gentner (1983) showed how the use of flowing water as an analogy for electricity could be generative, allowing the learner to make inferences from the analogy, although clearly it is inexact. It is difficult to envisage teaching concepts by analogy without the use of language but they may reduce the need for it. For some people it is clear that their preferred approach to problem-solving is by manipulating a much more concrete mental image; this approach comes more easily to some than to others but for many people mental imaging can be a powerful aid to memory. A number of children in our previous studies in the ISC (Brooke 1994, Brooke

and Solomon 1996), when asked if they remembered the activities there, made it clear from what they said and did that they were mentally walking round the room and mentally manipulating the equipment.

Cognitive and learning styles

There has been a recent increase of interest in individual cognitive and learning styles in both mainstream and special education (see also Section 2.3). Riding and Rayner (1998, p.8) defined cognitive style as ‘an individual’s preferred and habitual approach to organising and representing information’, and proposed two continua for these preferences: ‘wholist-analytic and verbal-imagery’. Others (e.g. Given and Reid 1999) have suggested a broader approach incorporating emotional, sociological, environmental and physiological aspects of the individual’s styles to produce a cognitive style map or profile (see Mortimore 2003). Learning styles are generally seen as the strategies employed by learners that relate to their cognitive style. However, Mortimore (2003) acknowledged that the area of cognitive and learning styles remains contested ground; there is no consensus, for example, on the extent to which cognitive style is something ‘genetically determined and fixed or environmentally developed and changeable’ (p.8), although she noted that there is increasing evidence for a combination of these factors; that is, a genetic pre-disposition to a particular style of processing, shaped by experience. Further disagreement exists over the extent to which cognitive styles may change as part of a general, staged developmental process or are specific to particular situation or tasks.

A number of authors (e.g. Dunn and Dunn 1991, Given and Reid 1999) have claimed that a match between style preference and presentation promotes learning success. Mortimore

(2003, p.27), while citing overall evidence in support of this view, again sounded a word of caution, noting that some research has been criticised for the fact that this success could have been attributed to a range of other influences, including teacher skill and student motivation. Riding and Rayner (1998) concluded from a series of studies that learning performance is affected by the interaction between cognitive style and three aspects of study material: the structure of the material, the mode of presentation and the type of content. The importance of mode of presentation was of particular concern for this study and will be explored later.

It may seem self-evident that ‘if a student cannot learn in the way a teacher teaches, the teacher must teach in the way the student learns’ (Chasty 1985) but Tilstone *et al* (2000) and Mortimore (2003) have pointed out the pragmatic difficulties faced by a teacher attempting to teach to the individual learning profiles of every member of the class. Both Mortimore and Tilstone *et al* see students’ awareness of their own learning styles and more general metacognitive skills as one element in solving this dilemma; the application of theories about learning style and metacognition in special/inclusive education will be taken up in Section 2.3.

Multi-sensory learning

The idea of learning through the senses is a very ancient one and yet, as Gardner (1983) and Hodgkin (1985) pointed out, there exists a hierarchy in education in which language, whether written or spoken, is seen as the superior medium for the transmission of knowledge. It is increasingly recognised that different learners favour different input modes and yet this hierarchy remains. Particularly at secondary level, learning through

other than auditory means – visual or kinaesthetic for example – tends to be considered second best, only appropriate to the primary classroom (or for those with special educational needs). Science could perhaps be seen as an exception, taught even in secondary school through practical experiments following the empirical tradition; however, secondary school students tend to be told what experiment to carry out in order to illustrate a point, they rarely explore.

The great majority of people are multi-sensory learners; we may learn more easily through one sense than another but learn best when one reinforces another. It is easier to understand water pressure if this has been felt or the principle of a fulcrum if we have played on a see-saw. Atkinson and Shiffrin (1968) proposed a multi-store model of memory in which incoming sensory information is stored briefly before being selectively attended to and transferred to the working memory. Whitebread (2000, p.124) maintained that ‘different pieces of information coming in through the same sense modality tend to interfere with one another,’ whereas related information through different sense channels or modalities support and reinforce. He concluded that ‘a multi-sensory approach to activities designed to help children’s learning is likely to be the most successful.’

For those who have difficulty learning, for whom language is a difficult medium, and in whom one or more senses may be impaired, it seems obvious that multi-sensory input will be beneficial. Babbage, Byers and Redding (1999, p.72) noted, for example, that ‘a learner may feel at ease working from visually-oriented materials like pictures or symbols and significantly stressed by the prospect of following verbal instructions’.

2.1.3 Play and informal learning

A common feature of ISCs is the emphasis on learning through channels other than auditory (visual, haptic/kinaesthetic, occasionally olfactory or even gustatory); they are places where hands-on learning and 'playing about' is acceptable for all ages. The ISC in which the present research took place was based on a view of play as essential to development and learning and our previous research (Brooke 1994; Brooke and Solomon 1996, 1998) was designed to explore the relationship between playing and learning during visits to the centre by mainstream primary school groups (see Section 2.2). This relationship had important implications for the research reported here.

'Who would dare study play?' asked Jerome Bruner (1976). The answer is of course a great number of the most eminent theoreticians dating back to antiquity. Millar (1968) provided a comprehensive review of studies of play from the time of Plato and Aristotle to the late 1960s, a period which saw an upsurge of interest in the relationship between play and learning, due at least in part to the influence of Piaget. As has been noted above, cognitive development based on interaction with the environment was central to his theories and for the young child much of this interaction is play. Piaget himself (1951) divided play into three types: mastery or practice play, symbolic or imaginary play and games with rules; one taking over from another as the child develops.

Vygotsky, in a lecture given in 1933 entitled 'Play and its Role in the Mental Development of the Child', focused on the imaginary aspect of play. He described play as creating a 'zone of proximal development' for the child: 'in play a child always behaves

beyond his average age, above his daily behaviour; in play it is as though he were a head taller than himself' (Vygotsky 1978, p.102). Although play can, of course, also provide just the reverse; a situation in which the child can give her/himself permission to be younger, to be a baby again.

Moyles (2005, p.3) included the following in a long list of skills fostered by play:

'making choices; generating decisions; showing independence in thought and imagination; intrinsic motivation; experimenting, exploring and investigating ideas and objects'. And yet, as she pointed out, in school play generally takes second place to 'work', even in some early years settings, and is increasingly squeezed out by curriculum initiatives and targets as children move up through school.

In 1976 Bruner, Jolly and Sylva compiled a book of writings on play by a large number of authors including Piaget and Vygotsky. This work highlighted the elusive and disputed nature of play as a concept and its role in development and learning. Each of the contributing authors in Bruner *et al's* collection had their own definition of play but the characteristics listed by Sylva, Bruner and Genova (1976, p.244-245) provide a useful starting point. These are:

1. The dominance of means over ends.
2. The lessening of physical risk and of risk of failure.
3. A temporary moratorium on frustration due to the precedence of process over product.
4. Free attention. The freedom to notice seemingly irrelevant detail.
5. Voluntary activity. Play behaviour is self-initiated.

Points 2, 3 and 4 all seem to depend upon the first: while a child is involved in an activity in which there is no external or internal pressure to achieve any specified end-point, there can be no worry about non-achievement. However, there seems also a significant omission in Sylva et al's list: that of enjoyment. Play may be obviously enjoyable when it involves make-believe or jokes or it may provoke a quiet and serious satisfaction, or even something approaching pain in the case of certain sporting activities, but it is hard to imagine an activity that gives no kind of pleasure being described as play. These characteristics of play proved to be important for the present research as they had for developments in the interactive movement in special education (McConkey, 1981, 1985; Smith *et al* 1983; Nind and Hewett 2004 - see Section 2.3).

Transition from play to other types of activity

Millar (1968) and others have pointed out that there is a connection in both animals and children between play and tool use. Bruner (1976) saw play as central to the acquisition of skills in offering the opportunity to try different combinations of behaviour:

What appears to be at stake in play is the opportunity for assembling and reassembling behaviour sequences for skilled action. That at least is one function of play. (Bruner 1976, p.15)

This 'combinatorial' play goes beyond acquiring simple skills. It can be used to explore the components and sub-routines of a complex task, including that of language acquisition.

Polanyi (1958) described how we learn to use tools so that they become almost a part of our bodies. The raised hammer is an extension of our arm and its head the re-located

focus of attention as we bring it down on a nail; the car is an extension of our body as we inch it through a narrow space. This sort of body learning about objects produces the 'in-dwelling' or tacit knowledge discussed above. There is a link between this type of activity and Piaget's first category of play: practice or mastery play. It may be that a sense of control and competence is a necessary precursor to exploration. Solomon (1980) pointed out that in school science clubs it is common, even at secondary level, for pupils to ask for the same equipment time after time, and to do much the same things with it each time. This is often disappointing to the teacher who hopes for regular progression and creativity. In most cases innovation does finally occur, but only after this prolonged period of repetition.

Hodgkin (1985) described a process of movement between play and tool-use (practice) on the one hand and play and exploration on the other, which he envisaged as a double loop taking place in 'potential space':

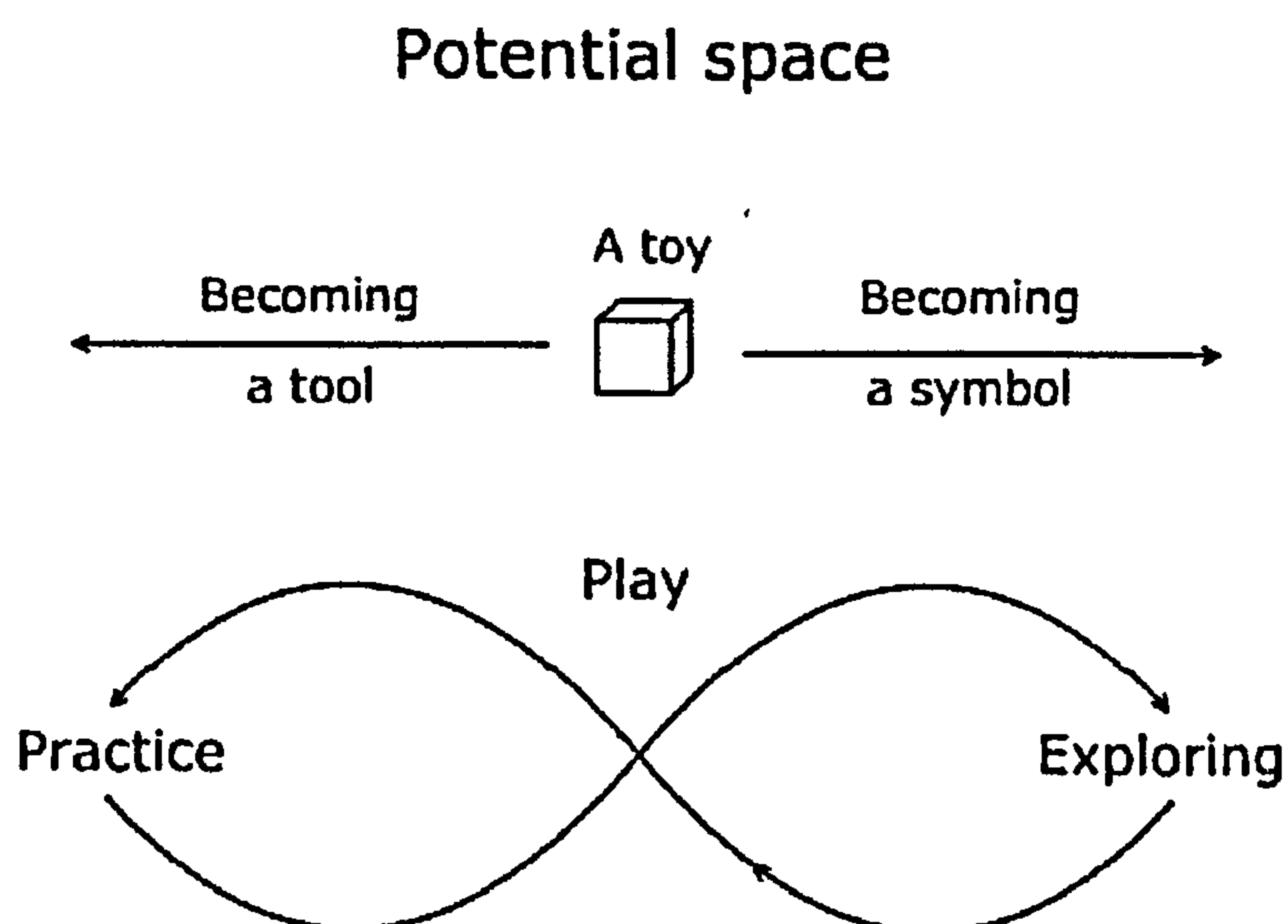


Figure 1: Cycle of Creativity (after Hodgkin 1985, p.46)

It is play with its freedom from pressure that provides the space necessary for the learner to use skills, once acquired, in a new area.

Play and problem-solving

Sylva, Bruner and Genova (1976) carried out a classic experiment on play and problem-solving with children aged between three and five years:

[The children] had the task of fishing a prize from a latched box out of reach. To do so they had to extend two sticks by clamping them together. The children were given various 'training' procedures beforehand, including demonstration of the principle of clamping two sticks together, or practice in fastening clamps on single sticks, or an opportunity to watch the experimenter carry out the task. One group was simply allowed to play with the materials. This group did as well in solving the problem as the ones who had been given a demonstration of the principle of clamping the sticks together, and better than any of the other groups. (Bruner *et al* 1976, p.16)

It appears from this result that being shown how to carry out a complete activity, or practising half of it, was not as powerful for successful problem-solving as uninstructed play with the whole of the equipment. Interestingly this experiment was cited by McConkey (1981) in a paper in which he suggested that the use of behaviourally-based methods in special education was promoting education without understanding; both he and Smith *et al* (1983) saw the lack of opportunity for this type of play as one factor in this. These issues will be further discussed in Section 2.3.

Informal learning

Play represents, of course, a particular type of informal learning, one aspect of the learning which precedes school, and continues alongside it, but it is by no means the only

one. Martin (2004) noted that recent studies of informal learning have tended to focus on non-westernized societies (e.g. Cole 1996, Rogoff 2003). Nevertheless the characteristics of informal learning, as opposed to ‘learning in westernized school settings’ that Martin (2004 p.75) lists could equally well apply to much learning in western societies taking place outside school, notably that such learning:

- occurs in the course of mundane adult activities;
- occurs in families;
- fosters traditionalism;
- fuses emotional and intellectual domains;
- is strongly observational and participatory;
- occurs where meaning is intrinsic to context.

The context-related nature of both school and informal learning and the extent to which it is possible to transfer from one to another has been the subject of extensive debate in recent years (see Section 2.1.5). Rampal (2003) described the different mathematical techniques used by an Indian market woman and her school-taught daughter and the difficulty each had in using their methods in the other’s context. The increasing awareness of socio-cultural factors in learning has been a focus of recent research in interactive science centres and other centres of informal learning (see Section 2.2).

The interactive science centre (ISC) movement arose in the USA in the late 1960s following a period of increasing disillusion with behaviourist psychology and increased interest in constructivism. It was also a time of questioning of traditional teaching methods (e.g. Holt 1990) and interest in informal learning. Frank Oppenheimer, founder

of one of the first ISCs, frequently pointed out that no one ever flunked a museum (Allen, 2004). Solomon (2003, p.4) has argued in an exploration of autodidacticism that 'the wish of autodidacts *not* to be taught in certain ways is coupled with a great wish to learn for and by themselves', in other words to be in control of their own learning. One function of ISCs, as of all museums, must be to provide an opportunity for independent and informal learning.

Locus of control and motivation

An important feature of play, and of most types of informal learning, is that it is voluntary, the learner is in control of whether or not to continue with the activity. The concept of 'locus of control' - whether control comes from within the individual or whether, as in the behavioural approach, control is external - and the consequent effect on learning behaviour, particularly motivation, were important issues in the behavioural/interactive debate in special education (see Section 2.3) and proved to be of central importance for the present research.

Also significant was the related concept of 'learned helplessness' developed by Seligman (1975), who suggested that this could result from a sense of lack of control. Authors in the field of special education have pointed out how this passivity can be induced both by the behavioural methods that seek to eliminate failure (Byers 1994) and by too great an experience of failure (Griffiths 1994 - see Section 2.3). Play can be seen to provide a context in which failure does not discourage and the playful nature of the activities at the ISC may have been an important factor in the students' responses to them. It also became clear that the intervention of other people during visits to the science centre could be both

motivating and de-motivating for students participating in the present research; it was increasingly apparent that locus of control was an important factor in this distinction.

Boekaerts (1994) has suggested that what she termed ‘instructional density’ in teaching could both increase anxiety and reduce motivation. Berlyne’s (1960) research with young infants, who showed optimum interest when shown displays that were neither too simple nor too complex, suggested that information that is either too complicated or too familiar can de-motivate and led to the formulation of his now well-known arousal curve:

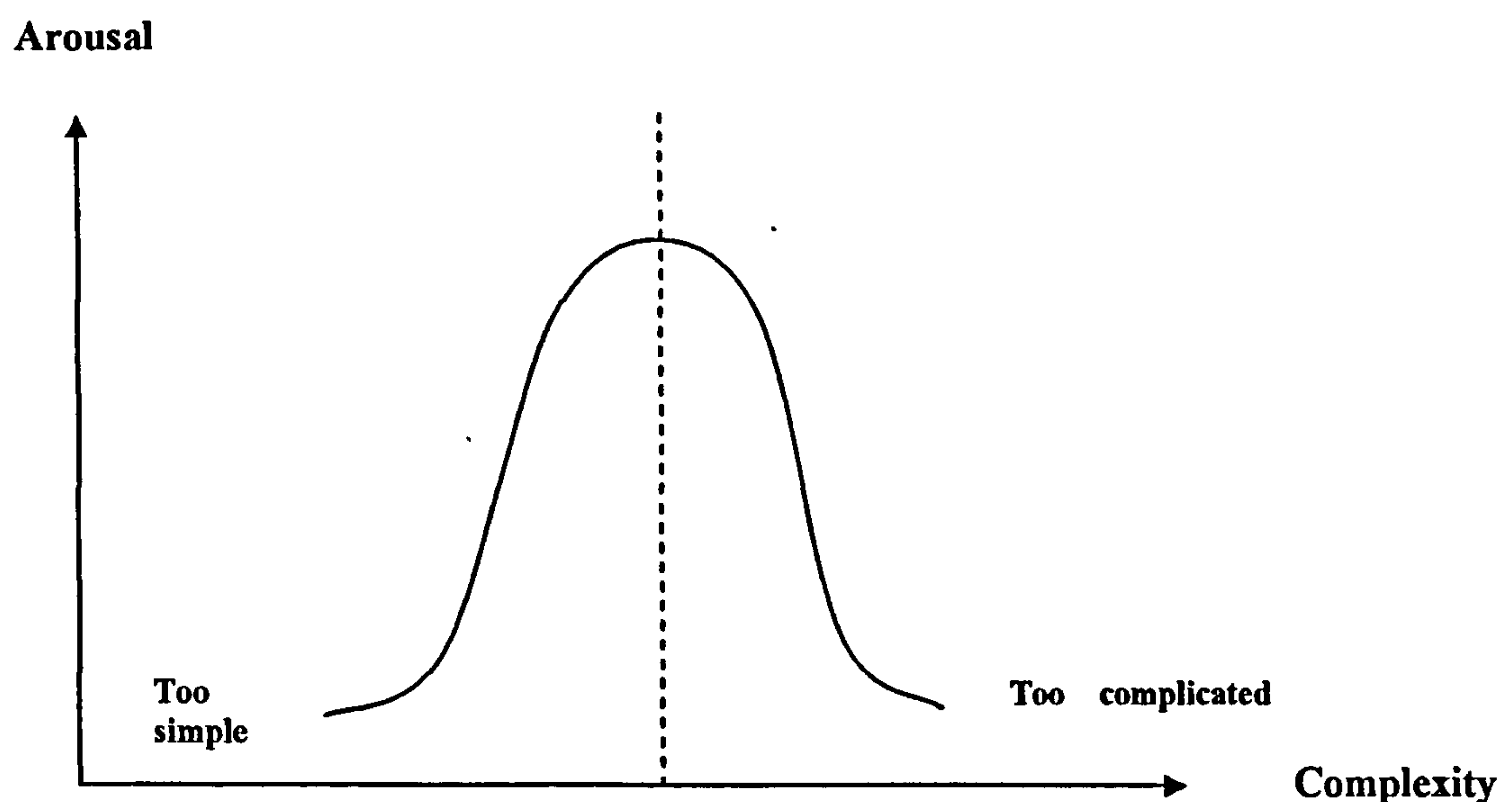


Figure 2: Arousal related to comprehension (after Berlyne 1960)

Motivation, then, relates to both control and ‘arousal’. Factors relating to choice and control and to the nature of exhibits – the need for them to be both stimulating and apprehensible - have been increasingly recognised as central to the motivation of visitors

and the success, or otherwise, of visits to ISCs and other centres of informal learning (see Section 2.2). Falk (2004) has suggested that ‘motivation is a fundamental but historically under-appreciated part of learning’, attributing this to the fact that, historically, educational research took place in laboratory or school settings ‘in which the motivations of the learner were considered of little importance’ (p.88). In free-choice learning situations, he maintained, ‘motivation emerges as central; influencing not only the “what” of learning but also the “why” and the “how”’ (p.88). Visits by participants in the present research were not, of course, entirely voluntary in the sense that it was a school trip, however it was made clear to the students that it was up to them what they did in the ISC.

2.1.4 Socio-cultural theory and social constructivism

The socio-cultural dimension of learning has assumed increasing importance in educational research in recent years, building on the work of Vygotsky (1978) and others (e.g. Vygotsky and Luria 1994; Bruner 1996; Rogoff 2003). There is increasing support for a view of learning as a cultural practice and recognition that ‘learning both outside and inside school, advances through collaborative social interaction and the social construction of knowledge’ (Brown, Collins and Duguid 1989, p.40).

The role of others in learning appears to have been accorded minor importance in the original conception of ISCs, although much more in recent years where the socio-cultural framework has been the focus of a significant body of research (see Section 2.2). It was also an element that assumed increasing importance for this research as it progressed and it became clear that interventions from other people were a significant factor in the students’ responses to the ISC, although not necessarily a positive one.

The theories of Vygotsky, first published in English in the early 1960s, as well as those of Bruner and others, that have become known as social constructivism, placed a much greater emphasis on the role of others - teacher, expert or more advanced learner - and the social or cultural setting in which learning takes place, than Piagetian constructivism had done. This distinction was at the heart of one of the best known disagreements between Piaget and Vygotsky: both recognised a social element in learning but placed very different emphases on its importance. Piaget attributed relatively little significance to this aspect, considering that the child constructs knowledge through interactions with the environment, of which other people represent one facet. For Vygotsky it was fundamental: 'Human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them' (Vygotsky 1978, p.88).

The zone of proximal development

Vygotsky (1978) saw the child's supported achievements as being more indicative of their cognitive development than those which they were able to achieve alone. The area between the two he called the zone of proximal development (ZPD), which he defined as 'the distance between the actual developmental level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers' (Vygotsky 1978, p.86). In order to promote development, Vygotsky stressed, teaching must be aimed at the ZPD; if it is beyond this level the child will be unable to make sense of it, if it is restricted to the child's actual level of achievement it is likely to limit development.

Where two children have apparently reached the same level of development their zones of *potential* development, in other words what they can achieve with assistance, may nevertheless be quite different.

Expert scaffolding

The term scaffolding was originally coined by Wood, Bruner and Ross (1976) to describe the process by which the adult or 'expert' helps somebody who is less adult or less expert:

More often than not it involves a kind of 'scaffolding' process that enables a child or novice to solve a problem, carry out a task or achieve a goal, which would be beyond his unassisted efforts.
(Wood, Bruner and Ross 1976, p.90)

The powerful metaphor of a structure that can be gradually removed when it is no longer needed has been much used since. Wood (1998) also speaks of 'contingent support', increasing or reducing input according to the learners' needs, a concept that is important in interactive approaches in special education (see Section 2.3) and proved to be very important in the research reported here.

2.1.5 Flexible learning: transfer and generalisation

The recognition of learning as situated in social and cultural contexts has highlighted the question of the extent to which it can be transferred from one task to another or generalised to other contexts. The details of debates concerning the degree to which learning is 'situated' are beyond the scope of this research. It may be that certain types of learning are not easily transferred from everyday life to the classroom or vice versa, however, the idea of teaching certain skills, for example thinking skills or metacognition, presupposes a belief that these can be generalised. Rogoff and Gardner (1984, p.95),

pointed out that ‘people are clearly able to generalize some aspects of existing knowledge and skills to new situations’. They suggested that one way of achieving this is by helping the learner to create bridges between what is already known and new learning through a process they termed ‘guided participation’.

Rennie and Johnston (2004) see the ability to make connections, to generalise to some extent from a learning experience, as central to the learning process, suggesting that meaning is made ‘through a constant process of remembering and connecting’ (p.6) . The role of language in the creation of such links, and implications for students with very limited language, will be discussed later as will other aspects of transfer and generalisation in relation to special education (Section 2.3). The question arose during the research of the extent to which the students’ responses to the ISC were simply a function of the trip out of school and whether they would remember and transfer anything from the experience to the school setting. Follow-up sessions in school were built into the design of the research to see if it was possible to gain any sense of this.

2.2 Historical and Conceptual Background to the Research

Setting

The aim of this section of the literature review is to set out the theoretical framework of the research setting, the historical background to the ISC movement and ideas that had been influential in its conception, as well as in the conception of the ISC where the research took place. It includes previous research in this and other ISCs.

2.2.1 Historical framework: the interactive science centre movement

The interactive science centre movement can be seen as originating at the end of the 1960s, although it was a development of a much older tradition of science museums and before them of science experiments as public entertainment. It came into being in North America at a time when behaviourist psychology had lost the ascendancy for the first time in decades; a time of renewed interest in learning through experience and a way of thinking that was heir to the educational theory of Dewey and influenced by Piagetian constructivist epistemology (Allen 2004). The Exploratorium, created in San Francisco in 1969 by physicist Frank Oppenheimer, was one of the first institutions to build and design 'hands-on' exhibits. Allen (2004) noted that the basis of Oppenheimer's approach to exhibits was compatible with Dewey's ideas, giving central importance to direct experience of phenomena, and presenting the learner with a problematic experience from which he or she could conduct genuine inquiry. It was also, she suggested, in keeping with the Piagetian notion of disequilibrium as a driver for learning.

Oppenheimer collaborated with psychologist Richard Gregory, creator of the first purpose-built ISC in the UK, the Bristol Exploratory (Rennie and McClafferty 1996).

Gregory was particularly interested in creating activities with a phenomenological perspective, an emphasis on the relationship between the senses and perception:

The experiments and demonstrations start with human perception: with the explorer-visitor finding out how his senses provide information to perceive and understand – and sometimes misperceive and misunderstand. For although the physical sciences aim at 'objective' knowledge by replacing the human observer, so far as possible, with instruments, ultimately it is our observations (even though sometimes via instruments) that convey our reality. (Gregory 1986, p.13)

The two decades following the creation of the Exploratorium saw a mushroom development of ISCs, first in North America, then in Britain, and a large number of other countries around the world. Although the nature of the early ISCs was heterogeneous, in general the twin objectives of informing and entertaining co-existed - Lucas (1991) coined the term 'info-tainment' - and many inevitably faced a certain conflict between their various aims of entertaining, informing or educating and profitability. Scepticism regarding the ability of such centres to resolve this conflict was expressed in a number of quarters, most notably by Shortland, who wrote in *Nature* in 1987: 'when education and entertainment are brought together under the same roof, education seems to be the loser' (p.213). This provocative statement stimulated a considerable body of research.

2.2.2 Research in ISCs

Research studies linked to ISCs up to the mid-1990s could be very loosely divided into two types, reflecting the twin aims of entertainment and education: those which studied visitor behaviour and those which attempted to find out how much had been learnt during a visit. Studies of visitor behaviour generally favoured qualitative methodology, such as visitor tracking techniques and observation forms (e.g. Eratuuli and Sneider 1990, Russell 1990, Diamond 1994). Those that aimed to find out how much had been learnt often used techniques such as pre- and post-testing (e.g. Borun 1977, Falk 1983, Heard 1992).

Feher (1990) attempted to study the effects of exhibits on visitors' mental models by asking visitors to make predictions, using drawings, prior to seeing the effect of a light and shadow exhibit (the shadows produced by cross-shaped or red and green light sources). Once they had seen the shadows, if their prediction had been wrong, as it

usually was, they were asked to adjust their drawings. Feher found that participants' new models were often no more 'correct' than the old, indeed visitors would often go to some lengths to make the evidence fit their existing model rather than the reverse.

Stevenson (1991) combined tracking of visitors with interviews immediately post-visit and six months later. He found 'what' had been done to be highly memorable and that 'there was evidence that visitors thought about what they were doing' and that 'a large proportion of visitors' thoughts were accurate or appropriate' suggesting, he claimed, that 'cognitive processing does take place', nevertheless 'most of this thinking was concerned with 'effects' rather than 'explanations' or 'understandings'' (p.530).

However, Shortland's question as to the compatibility of education and entertainment remained largely unanswered by these studies. Wellington (1990) concluded from a review of ISCs in a number of countries that any learning was purely in the psychomotor and affective spheres and most studies reached similar conclusions. More recent research, based on a more complex picture of the learning process and the role of centres of informal learning within this, suggested that Shortland's question may have been based on a false dichotomy. Falk (2004) described research in the early 1990s as based on a prevailing behaviourist model of museum learning. He stressed the need to understand factors influencing learning in museums holistically and the museum visit as part of a much larger whole, placing it in its social and cultural context.³

³ The term 'museum' is used in this context to cover a wide range of centres designed for informal learning: galleries and zoos as well as ISCs and more traditional museums.

Falk and Dierking (1992, p.5) developed what they termed an Interactive Experience Model, which stressed the importance of physical, social and personal contexts for learning in museums. This model provided the foundation for a new generation of museum research over the next decade, which showed much greater recognition of the complexities of the learning process and a particular interest in the socio-cultural paradigm. Rennie and Johnston (2004, p.4), building on Falk and Dierking's model, suggested 'that three characteristics of learning, its personal nature, that it is contextualized and that it takes time, are critical to understanding and investigating the impact that museums have on people's lives'. These categories are of particular interest for the current research.

Learning is personal

Allen (2004) noted that theories concerning the diversity of learners have influenced museum research and design of exhibits in recent years, notably Gardner's (1983) theory of multiple intelligences; theories concerning cognitive and learning styles discussed above and 'the recognition of different sensory modes of experience: visual, auditory, tactile, smell and even taste' (pp.27-28).

Another facet of the personal dimension of learning that has been a feature of recent research in informal settings has been that of choice and control and their relationship to intrinsic motivation. Recent studies have shown the importance of these factors (e.g. Falk and Dierking 2000, Paris 1997) in informal settings where 'visitors ... choose to visit and whether or not to take advantage of the learning opportunities' (Rennie and Johnston 2004, p.6). Paris, Yanbour and Packard (1998, p.271) described museums as

environments that inherently foster intrinsic motivation, where people ‘construct personal meaning, have genuine choices, encounter challenging tasks, take control over their learning, collaborate with others, and feel positive about their efforts’. Csikszentmihalyi and Hermanson (1995) in a study of intrinsic motivation in museums characterised ideal learning at exhibits as initially driven by curiosity and interest, and then maintained via a ‘flow’ state in which visitors become involved with mind and body. Griffin (2004, p.62) noted that when students described a visit to a museum as ‘fun’ this appeared to incorporate ‘a complex notion that includes feelings of mastery and control’. Relationships between choice, control and motivation have also proved to be central to the current research.

Learning is contextualized

Falk and Dierking (1992, p.6) postulated that three contexts, the personal, social and physical, interact to produce the nature and outcomes of the visitor’s museum experience: not only *what* happens but *where* and *with whom*. The personal context has been discussed in the previous paragraph; the physical context includes design of the museum space and of the exhibits. Recent museum research has emphasised the social context and the socio-cultural dimension of learning: the role of social interaction, within group socio-cultural mediation, and facilitated mediation by others (Rennie and Johnston 2004, Martin 2004). There is a tendency to emphasise the positive impact of the family group: ‘family members engage in a variety of strategies that encourage explanation and understanding’ (Martin 2004, p.73), although dynamics within these are presumably not invariably positive.

Storksdieck and Falk (reported in Falk 2004, p.86) undertook an ambitious project in which they attempted to investigate the impact on visitor learning of ‘dozens of factors’ and found that prior knowledge, interest, motivation, choice and control, within group social interaction and between group social interaction, as well as physical features such as architecture and the quality and quantity of exhibits all ‘significantly influence learning for at least some visitors’ but that no single factor stood out.

Learning takes time

Recognition that learning is contextualized raises the question of how easily anything learnt in a museum visit is transferred to other contexts. Rennie and Johnston (2004) suggested that time is a vital element in this process:

Learning involves making links to, or between, previously separate ideas, or the potential to make new links in the future... the cumulative nature of learning means that the significant impact of a museum visit is likely to occur sometime later. (Rennie and Johnston 2004, pp.7-8).

Falk (2004, pp.89-90) similarly maintained that our ‘brains build understandings through continuous process of perceiving new patterns, images and ideas and accommodating them within existing structures’ and that ‘recent evidence suggests that memories are only partially laid down at the time of the event’. He reviewed a series of longitudinal studies that have shown that learning from a museum visit does change over time and ‘not always by declining’ (Falk 2004 p.91).

Martin (2004, p.74) claimed that ‘studies of museum learning in science centers show learning from museum visits to be detectable and manipulable’; nevertheless there is increasing recognition of the museum visit as only a ‘tiny thread woven into the tapestry

of the visitors' life experiences' (Rennie and Johnston 2004, p.13). Martin (2004) recognised the challenge this view of learning presents to museum researchers: clearly the pre-test/post-test design or even the questionnaire at the end of a visit can no longer be seen as valid means of measuring learning from the visit. It also presented particular challenges for the present research, where participants had limited language; follow-up activities were designed to gain an idea both of what students remembered some time after a visit and whether they could transfer this to a different setting and slightly different activities.

Formal versus informal settings

Griffin (2004, p.60) maintained that 'a major impediment to learning during field trips has been that teaching strategies appropriate to a formal setting are often being imposed in museums', noting, for example, a student's comments on the use of worksheets: 'we didn't learn anything because most of it went in through the eyes and out through the pen onto the paper' (p.62). She suggested that school visits should be modelled more closely on family visits, particularly with regard to choice, control and ownership of learning (Griffin 1998). Other factors that have been found to enhance learning from school visits were encouragement of interaction between peers, preparation and follow-up that helped students make connections between the visit and school learning (Wolins *et al* 1992), and quality of mediation during the visit (Schauble *et al* 2002). In one study (Griffin *et al* 2003, reported in Griffin 2004) students were asked to carry tape recorders with lapel microphones and were found, when moving freely around, to be 'conducting learning-related conversations eighty percent of the time,' although this raises the question of the extent to which the tape recorders may have influenced the conversations.

Griffin (2004) noted that teachers accompanying students on a visit tended to have either a survey agenda, characterized by the use of worksheets that had little to do with the school curriculum, or a concept agenda, linking the visit to school topics. She recognised the constraints under which teachers operate, including curriculum controls and logistical considerations, as well as personal perceptions and expectations.

Exhibit design

One factor that has been found to be important in the success or otherwise of visits to interactive science centres – whether for family or school visits – is the design of exhibits. Allen (2004, p.17) wrote of the ‘constructivist dilemma’ faced by exhibit designers attempting to design activities that are intrinsically motivating and that enable a very diverse visiting public to learn by making personal choices. She described their aim as being to create exhibits that promote the ‘cycle of enquiry’: presenting the learner with a problematic, puzzling or surprising phenomenon leading to exploration. Curiosity is the starting point for Csikszentmihalyi and Hermanson’s (1995) ‘flow state’ of intrinsic motivation, described above, and was found to be an important precursor to exploration in our previous research in the ISC (Brooke and Solomon, 1998). Allen (2004) further described the importance of ‘apprehendability’, and getting a balance, as in Berlyne’s (1960) arousal curve, between sufficient complexity or novelty to arouse curiosity and the over-complexity that de-motivates. Other factors in exhibit design that were found to be significant were physical interactivity, conceptual coherence and diversity of learning modes (Allen 2004, p.20).

2.2.3 Previous research in the ISC that is the setting for this study

The ISC that was the setting for this study was unlike the commercial science centres that grew up in the 1980s and 90s in the UK in a number of ways (apart from being possibly the smallest), most notably in having the ‘fourth generation’ exhibits described in the introduction, which allowed visitors to design their own investigations if they were so inclined and to make their own discoveries.

Initial observations at this small ISC had suggested that learning was indeed taking place, as well as the children having great fun. We set out to study the relationship between play and learning in the ISC (Brooke 1994, Brooke and Solomon 1996). Interviews with over eighty children, either immediately after a visit or after an interval of up to three months, showed that not only did almost all the children have excellent recall of what they had done at the science centre but many were able to provide explanations for what they had observed and some to apply these to new, hypothetical, problems (Brooke 1994, Brooke and Solomon 1996). It was clear from our observations at the ISC that many of the children moved on from playing to investigation to their own agenda and curiosity, and therefore interest in cause and effect, appeared to be a vital ingredient in this movement from play without purpose to investigation for these visitors. Building on Hodgkin’s (1985) model of play and exploration and on Bruner’s (1976) view of play discussed above, we proposed the following model for what had been observed at the ISC with mainstream groups:

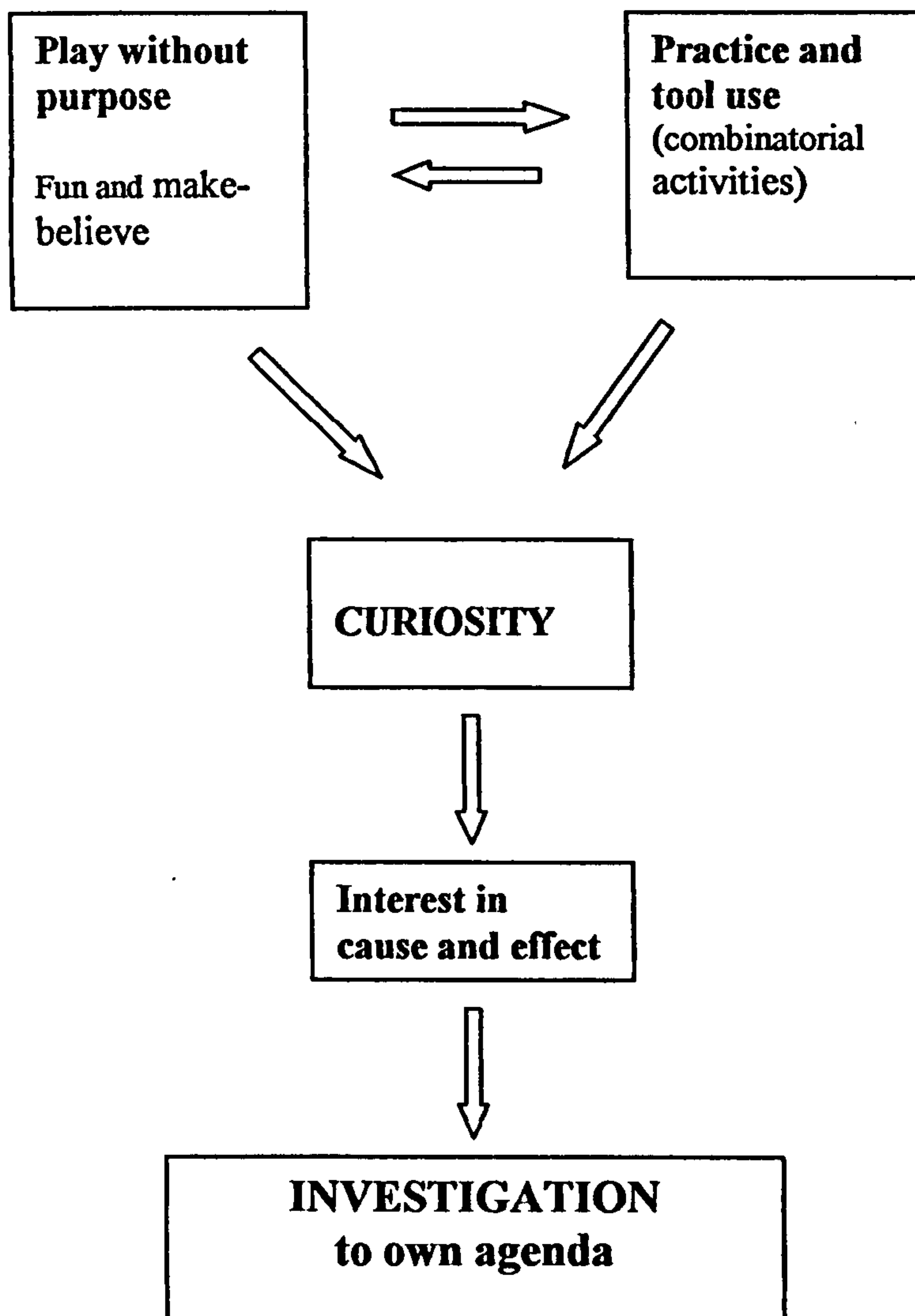


Figure 3 (from Brooke and Solomon 1998)

This research formed a part of the background, or, in grounded theory terms, theoretical sensitivity, that informed the design of the present study.

2.3 Pedagogy in Special Education

This section of the Literature Review again has a dual purpose:

- to situate the students' usual educational environment within a historical and theoretical framework.
- to outline ideas that have influenced debates concerning pedagogy, particularly in special education, that have been important for the research and to situate the research and the contribution it has to offer within these debates.

Many of the epistemological and pedagogical issues outlined in Section 2.1 will be revisited here but from a special or inclusive education perspective.

2.3.1 The historical context: the rise of behavioural approaches

It is necessary to consider some (relatively recent) events in the history of special education in order to understand how the emphases on different pedagogical theories in special and in mainstream education came to be so different; in particular how behaviourism gained in influence in the field of special education at a time when its influence was waning in mainstream.

Prior to 1944 the 'mentally deficient', as they were then termed, were diagnosed, classified and cared for under a medical model. The 1944 Education Act had made some attempt to bring the education of 'handicapped' children back into the education sector (see Tilstone 1991) but around ten percent of these children were still considered

‘ineducable’ and the responsibility of the Local Health Authority. Any education that they received took place in Occupation Centres (later re-named Junior Training Centres) and many lived in residential institutions. Young people classified as ‘subnormal’ or ‘severely subnormal’ according to IQ testing following the 1959 Mental Health Act had been assumed to be mentally, emotionally and socially immature and teaching tended to be based on ‘a nursery/infant curriculum regardless of the age of the pupil’ (Tilstone 1991, p.11).

In 1970, the Education (Handicapped Children) Act transferred the responsibility for the education of even the ‘severely subnormal’ from the Health Authorities to the Local Education Authorities. The Junior Training Centres became special schools delivering special education and teachers found themselves faced with a new challenge. Methods based on the work of the behavioural psychologists, and notably the work of B.F. Skinner in the USA, became very popular at this time in the new special schools and were embraced with some relief, as Byers (1994) described:

Teachers operating in something of a vacuum turned to psychologists and to the theory and practice of behaviourism for guidance and inspiration. In adopting a behaviourally-orientated, checklist driven model for the education of pupils with severe learning difficulties, teachers accepted hypotheses which were presented as *a priori* truths. (Byers 1994, p.78)

This was based on an assumption that young people with SLD did not learn in the same way as mainstream pupils. Crawford (1980, p.22), for example, maintained that (in the terminology of the time) ‘the ESN (S) child almost certainly has a damaged brain and nervous system. As a consequence of this, his development can be expected to be *different*’ (original emphasis). In particular, it was felt that these pupils could not simply ‘pick up’ learning and needed the much more structured approach offered by behavioural

methods. These were embraced more comprehensively by special educationalists than they had ever been in mainstream, at least in this country, and, interestingly, at a time when mainstream education was moving away from the influence of behaviourism. Teaching programmes such as EDY (Education of the Developmentally Young) (Foxen and McBrien 1981), the Skills Analysis Model (Gardner, Murphy and Crawford 1983) and Portage (White and Cameron 1986) typified this approach; task analysis was used to break skills down into sub-skills and then carefully formulated, behaviourally verifiable objectives were written linked to these. Techniques included 'backward or forward chaining', to link the sub-skills, and 'shaping' (of the behaviour).

Results were encouraging, at least in certain areas such as the teaching of self-help skills (see for example Sebba, Byers and Rose 1993); 'a feeling of optimism was in the air; children were doing many things they had not been doing before' (Smith 1989, p.113). By the 1980s methods based on behaviourist psychology represented the dominant pedagogy in special education: 'the vast majority of publications on teaching pupils with learning difficulties stressed the importance of the behavioural approach' (Farrell 1997, p47), to the extent that Wood and Shears maintained in 1986 that the idea 'that the child with severe learning difficulties has a need for this style of education is now taken as virtually a self-evident truth' (p.1).

2.3.2 Challenges to behaviourism

Nevertheless, from the early 1980s reservations were increasingly expressed about the use of behavioural methods in special education; despite Skinner's emphasis on positive reinforcement and the use of praise and encouragement, concerns were raised about the

harshness of some of the methods in practice, in particular some use of behaviour modification techniques (see for example Wood and Shears 1986, Byers 1994). If not actually harsh, behaviourist techniques were seen as limiting, success defined in terms of 'getting ticks for the acquisition of ordinary skills, usually learned informally, onto record sheets where before there were blank spaces' (Wood and Shears 1986 p.20). And increasingly questions were raised about whether skills developed in this way were being acquired with real understanding or transferred to other situations. McConkey (1981) in his seminal article entitled 'Education Without Understanding?' voiced this concern:

I wonder if by concentrating almost exclusively on products and outcomes we fail to help children acquire generalisable skills and develop a genuine understanding of the objects and events in their world which they can use to generate novel products? (McConkey 1981, p.9)

Even such skills as dressing did not necessarily transfer from classroom to home and language appeared to be particularly difficult to teach in any flexible way by these methods (Smith 1989).

Sugden (1989, p.20) summarised further criticisms of the behaviourist approach from a cognitive standpoint: the reductionist nature of the approach itself; the fact that it is difficult to capture the educational process in stark behavioural objectives; that the approach does not take into account the cognitive processes, thus the learning processes of the child; and that there is an assumption that a child's learning is externally driven and directed. Wood and Shears (1986), in a detailed critique of behavioural methods, went further in suggesting that 'for children with severe learning difficulties the consequences of the objectives/skills analysis approach are ... to confirm the children's dependence, their inabilities and difference from the norm' (p.26). They attacked the idea

of 'normalisation', suggesting that the attempt to teach skills 'as a passport to participation and acceptance in the dominant living patterns and culture of mainstream society' is both illusory and 'devalues [children with severe learning difficulties] in terms of the people they actually are' (p.3). Discussion of the concept of normalisation will be taken up again later.

Locus of control and learned helplessness

The concept of 'locus of control' and the related concept of 'learned helplessness', discussed above, were issues that increasingly pre-occupied special educators in the late 1980s/early 1990s. Wood and Shears (1986, p.31) suggested that the objectives/skills analysis approach 'is not about learning to be independent except in the narrowest of definitions'. Byers (1994) highlighted the paradoxical nature of teaching methods that purport to *train* students to be independent:

Teachers in schools for pupils with learning difficulties have a characteristic complaint, focused on perceived shortcomings in the pupils themselves, which suggests that in spite of years of careful training, pupils somehow lack the self-confidence to go out and put their skills in practice in the real world. (Byers 1994, p.88)

This paradox was reflected in the interviews with teachers carried out for this research: the simultaneous desire to see the students do more independently and the conviction that they needed constantly to be told what to do.

Byers (1994) attributed pupils' passivity and dependence to a pedagogy where the teacher is in complete control of the task, breaking it down until failure is eradicated, stating that:

It is unlikely ... that pupils who have been encouraged throughout their school careers to be the passive recipients of a system of instruction, which seeks to eradicate failure and guarantee success will suddenly become proactive adults brimming with self-confidence simply because they are confronted with the challenges of the real world. (Byers 1994, p.88)

Griffiths (1994) suggested that special schools could be reinforcing coping strategies developed by people with learning disabilities, particularly that of passivity, of waiting to be told or waiting to be shown before doing anything ‘in a bid to make children acceptable and over-conformist to compensate for the perceived disadvantages of disability’ (p.9).

Learned helplessness may result from too great an experience of failure as well as too little. Watson (1996 p.3), noted that ‘anxiety, experience of past failures, lack of confidence and a tendency to withdraw from, rather than engage with, challenge, are very frequently found among pupils receiving special education’. Such pupils, she suggested, tend to attribute failure to their own low ability and those who ‘have encountered repeated difficulty in school are also likely to react to new challenges or difficulties in a defeatist negative way’ (p.10).

Wishart (1996) set out to investigate why early progress made by children with Down syndrome is often not maintained. She noted that these children ‘often change from being active and relatively able problem solvers into progressively more reluctant learners’ (p.173) and suggested that avoidant learning strategies may be linked to the ‘Down’s syndrome child’s’ (sic) perception of him or herself as a learner:

Given the inherent difficulties they have in learning new skills, it would seem highly plausible that their belief in their own efficacy as learners would not be strong and that enthusiasm for learning might wane as age increases and experience of failure grows. (Wishart 1996, p.183)

Wishart (1996) concluded that it is necessary to look more closely at the contexts provided for the learning of these children, that greater insight is needed into the ways they interpret and respond to the successes and failures they encounter, to find ways of supporting their learning that do not encourage them to relinquish much of the learning initiative to others. Garner, Hinchcliffe and Sandow (1995, p.84) suggested that 'our styles of teaching and management often rely on too much use of dominance and compulsion' and advocated looking for ways of encouraging genuine participation. The effect of teacher-directiveness on independent action and interaction proved to be a significant consideration in analysis of student behaviour in the ISC.

Play, it might be thought, would be an area in which the child would feel in control, yet Jobling (1996 p.228-9) describes 'free' play sessions in special schools being used to focus on targeted objectives from the children's individual education programmes. However this could not be considered play according to Sylva et al's (1976) definition used for our previous research in the ISC (see Section 2.2), a vital component being that it is task and target-free. The relationship between play and locus of control proved very important for the research.

2.3.3 Alternative approaches

From the early 1980s McConkey (1981) and others were advocating a return to a more interactive approach based on cognitive not behaviourist psychology. This they saw as

more likely to promote generalisation of learning and real understanding. In 1983 Smith, Moore and Phillips published a response to McConkey's 1981 article, this time entitled 'Education with Understanding?' advocating a process-centred, interactive approach rather than product-centred behaviourist methods. Two conferences in the late 1980s gathered together individuals interested in the application of interactive approaches to teaching children with special educational needs.

The interactive movement in special education, as it came to be seen, reflected the dual, if linked, sense of the term interactive noted above: interaction with the environment and, increasingly, interaction with other people. Collis and Lacey (1996) noted that the theories of Piaget and Vygotsky - whose differing emphases on these two aspects of interaction have been explored above - were a significant influence in the shift towards interactive approaches. Although by the 1980s Piaget's theories had been challenged from many quarters, they nevertheless provided a useful framework at a time when the view of children with learning difficulties as developing differently from others was being questioned; 'whether or not Piagetian theory is an adequate explanation of mental development, it does provide the framework of a developmental sequence which emphasises the way children function mentally' (Smith 1989, p114).

Interactions with the environment

As reservations about behaviourism grew, cognitive psychology and the Piagetian view of the child actively constructing meaning through interactions with the environment appeared increasingly attractive and more likely to produce flexible learning than behaviourist approaches. Multi-sensory rooms became increasingly popular in special

educational settings from the late 1980s, growing out of the 'snoezelen' movement which originated in the Netherlands in the 1970s. The term 'snoezelen' was coined in a large residential centre for people with mental disabilities 'to describe situations where residents could derive a sense of well-being and relaxation from a range of simple sensory experiences' (Bozic 1997, p.54). These were designed for the most severely disabled adult residents.

The idea rapidly gained popularity in the UK but Mount and Cavet (1995) sounded a note of caution, questioning whether positive results linked to such multi-sensory environments might not be due to other changes (for example time spent away from wards and increased staffing ratios) rather than to the environments themselves. They emphasised the need for rigorous research as well as for careful training of staff in the use of multi-sensory rooms and careful thought about how they were used:

At best a multi-sensory room can increase the alternatives available to people with profound and multiple learning difficulties and may be motivational for staff. At worst it may divert the attention of staff from recognising the potential for sensory stimulation in everyday environments and can provide an unstimulating and incomprehensible setting for people with learning difficulties. (Mount and Cavet 1995, p.54)

Bozic (1997) undertook a review of the use made of multi-sensory rooms in the UK, from which he concluded that 'the effects of educational technology cannot be evaluated in isolation from local aims and uses' (p.54). He pointed out that the 'snoezelen' idea originated in a situation where the carer was non-directive and residents had the power to choose and set the pace of activities; it was not specific to a particular place or time and learning was seen as a bonus, whereas in the UK it was largely adopted by institutions whose main goal was educational. Bozic (1997, p.54) sought to 'chart the ways that staff

construct the purpose and meaning of multi-sensory rooms in this new educational context'. Using discourse analysis methods to analyse transcripts of interviews with staff in four schools he identified two main interpretative repertoires: the child-led repertoire, closer to the original Dutch concept, 'in which the room is presented as a comfortable, relaxing place in which children are able to make their own decisions about the activities they become involved in' (Bozic 1997 pp.56-7) and the developmental repertoire which emphasised a view of the child progressing through stages or levels and the need to tailor activities to moving the individual on to the next stage, meeting the next target. The former repertoire includes the concepts of choice, control and participation, which assumed increasing importance for the present research and which are less evident in the latter discourse.

Interactions with others

Ware (2003, p.1) defined a responsive environment as 'an environment in which people get responses to their actions, get the opportunity to give responses to the actions of other, and have an opportunity to take the lead in interactions.' The notion of choice and control is central to this definition. Ware (2003, p.1) also reminded us that 'there are two ways in which people receive responses to their actions: from other people and from seeing things happen as a result of what they do' and it may be that the distinction that has been made here between interaction with others and with the physical world is a false one. Nevertheless, the interactive movement in special education has tended to emphasise interactions between people, often as mediators with the environment as in parent-infant interaction (e.g. Nind and Hewett 1994).

The social constructivism of Vygotsky and others discussed above, which attributes a far greater role to interactions with other people, gained increasing ground in special as in mainstream education in the late 1980s and early 1990s (see for example Smith 1990, Collis and Lacey 1996). Increasingly special educators were questioning the idea that people with SLD learn in a *qualitatively* different way and communication was seen as a vital element in their development that had not been adequately addressed by behavioural methods (e.g. McConkey 1988, Smith 1989). Research into language development carried out by Wells (1985, 1986) and Tizard and Hughes (1986) had highlighted the efficacy of natural parent-child interactions in language learning and of shared regulation within these: ‘mothers who tried to impose language on their children were nowhere near as successful as those who followed the child’s lead, showed interest and elaborated on his topic’ (Smith *et al* 1983, p.23). Ware (2003) summarised a number of studies that have shown a tendency of caregivers of children with disabilities to dominate interactions, to be less responsive and to give more commands; partly, she suggests, because they receive less response from the children, responses are slower in coming, or are less obvious, or because of a desire on the part of the caregivers to make these children respond more. Nevertheless other studies (Fraiberg 1974, Burford 1988) have shown a more complex and varied picture.

Nind and Hewett (1994), working with people with very severe learning difficulties, came to the conclusion that the most fundamental learning needs of their students ‘were almost always within the realm of communication and sociability’ (p.6). They developed a particular interactive approach that they termed ‘Intensive Interaction’ based on the type of child-led caregiver/infant interactions that were known to facilitate the natural

development of communication and sociability in a typical child. Prominent among these is the idea of 'contingent responding': in Intensive Interaction, as in caregiver/infant interactions, the member of staff responds to the student's initiations, giving them a sense of control, adjusting the nature of the interaction and the timing to the student (Nind and Hewett 1994 p.24). Intensive Interaction is based on a view that educational approaches should be 'person-appropriate', as opposed to 'the prescriptive stance of the strict age-appropriateness school of thought' (Nind and Hewett 1994, pp.15-16). This includes accepting that adults can benefit from play. Another attribute of this approach that is significant for the current discussion is the fact that it is generally task-free, process-based rather than outcomes-based (Nind and Hewett 1994). Task-free activity as a defining feature of play has been discussed earlier and was a characteristic of the activities at the ISC, or at least of the way in which the students were invited to use them, that assumed increasing importance for the research. Significantly Intensive Interaction is also designed to be *enjoyable* for both parties and an important aspect of this is its voluntary nature:

The central theme of mutual pleasure is linked with the philosophy of participation. If the learner is taking part for reasons other than that they want to, they are likely to be complying rather than participating.
(Nind & Hewett 1994 p.16).

Pleasure is the motivation behind the games that caregivers play with young infants and is surely a defining element of play, if strangely absent from Sylva *et al's* (1976) definition.

Re-locating control

Control can be seen to be a recurring theme in developments in special education and was one that proved to be central to the current research. McConkey (1988) noted that interactive games between infant and caregiver are often child-initiated and child-maintained, making them both safe and exciting. Being in control implies having a choice about what to do. Coupe O’Kane and Smith (1994), pointed out that choice should not be something that occurs on Friday afternoons or at milk time. A starting point in an educational setting, they suggested, may be students having choices among activities, choice about whether or not to engage in an activity, when to terminate it, alternative means of accomplishing an objective, choices of partners for activities.

Lacey (1991, p.93) noted that ‘it is difficult to foster decision-making and problem-solving if pupils are not offered choices ... learning through mistakes in a positive, accepting and secure environment can be highly effective.’ Again Sylva *et al*’s (1976) definition of play included ‘a temporary moratorium on frustration’ where mistakes can safely be made because there is no task and therefore no risk of being wrong. Ware (2003) has suggested that one reason that children with disabilities tend to experience less responsive environments is that their responses may be very slow; caregivers may not wait for the response or miss it when it does come and therefore assume the child to be *unable* to respond. The time that students appeared to need and wait at activities in the ISC, and the fact that they were given control over this, also emerged as an important element. Ware (2003) also noted that children’s interactions with the physical environment can be limited by the fact that the environment is not adapted to their physical capabilities. Smith (1994, p.2) suggested that it may well be that for people for

whom the environment is unresponsive or unrewarding, a behavioural state is reached which is akin to that of 'learned helplessness. Locus of control and the creation of an environment where students are able, safely, to exercise choice and control, have proved to be very important considerations for this study.

Control in a wider sense is allied to the question of self-advocacy. Smith (1994), while recognising the complexity of the concept of control, suggested that a pragmatic definition would be 'having an effect on the operation and outcomes of one's life' (p.1); a realistic aim, as she pointed out, for the majority of people, not only those with learning difficulties. Mittler (1996, p.1) described self-advocacy 'at its most basic individual level', as being 'concerned with the opportunity to make choices and decisions on day-to-day matters'. He stressed that this must begin in childhood. Tilstone (1991 p.32) noted that 'through the self-advocacy movement people with a range of disabilities are demanding the opportunities to make decisions and exercise choices about their own lives.'

Transferability and generalisability

Issues relating to transfer and generalisation of learning discussed earlier have been important in the behavioural/interactive debate in special education. A major concern raised in the 1980s regarding behaviourally-based methods was that they were producing learning that was not transferable. Interestingly for this thesis, McConkey (1985) hypothesised that an essential element that was lacking in behaviourally-based teaching was the opportunity to 'play about'. He described a year-long observational study of the way in which children with Down syndrome learnt a ring-stacking task when left to

themselves. Their activities included an exploratory, playful stage and McConkey suggested that it was this playing-about phase that enabled the children to make flexible use of what they had learnt when carrying out similar but not identical tasks. The exception was a child who had been taught the initial task using physical prompts; she learnt it more quickly than the others but then was not able to use what she had learnt in new situations. Similarly Smith *et al* (1983, p.21) pointed out that the normally developing child attains the skill required to feed himself 'via much investigation of the properties of the food other than for eating, and the properties of the spoon other than for shovelling food'. They suggested that the handicapped (sic) child misses out on underlying discoveries that promote true understanding when he is taught the end product behaviour 'by prompting, modelling, shaping and systematic reinforcement' however effective this may appear to be in the short-term.

One approach that has been proposed as part of the interactive repertoire is the development of metacognitive skills (e.g. Smith *et al* 1983). This type of approach was developed by a number of special educationalists in the 1980s, notably the Staff of Rectory Paddock School (1983) and Ashman and Conway (1989). The teaching of metacognitive skills or thinking skills (e.g. Fisher 1990) assumes the possibility of some degree of generalisation to other areas. Watson (1996) described scaffolded metacognition techniques and a process known as 'reciprocal teaching' (Palincsar 1986), in which the learners take it in turns to take on the role of discussion leader. The students in these studies have mainly had (in the US terminology of the original) 'mild to moderate learning disabilities' and techniques appear to rely on a fairly advanced level of language. However, Feuerstein (1980), used a process that he termed 'mediated learning'

to teach metacognition and thinking skills to the more severely disabled. His cognitive development programme, 'Instrumental Enrichment' (1980), included sets of tasks and exercises aimed at correcting such 'deficient learning behaviours' as 'unplanned, impulsive and unsystematic exploratory behaviour' as well as poor self-esteem (Smith 1994, p.8). However it has been pointed out (Smith 1994) that it is only effective if intensive efforts are made to apply the strategies in everyday situations to effect transfer or what Feuerstein terms 'bridging.' It may be that such bridging can take place without sophisticated language, nevertheless, Fisher (1990, p.8) in a discussion of the teaching of thinking skills emphasised the 'central role that language has to play in developing a child's understanding' and most thinking skills programmes are language dependent. One of the issues raised by the present study was how students with very little language can be helped to transfer and generalise from an experience such as the visit to the ISC.

The continuing debate

The use of behavioural methods in the education of children with SLD nevertheless continued to have its advocates. For some this was linked to a view of these children as developing differently; Buckley (1990) argued that behavioural methods represented a breakthrough in the education of children with SLD precisely because these children do not learn like others. A number of authors (e.g. Buckley 1990, Wishart 1996) have suggested that special education should be adapted to the particular way in which children with SLD develop. There is, however, no consensus on whether children with SLD actually develop differently from other children or simply at a slower rate and others (e.g. Nind and Hewett 1994) have argued strongly that in the absence of firm evidence to the contrary we should assume that all children develop in the same way albeit at

different rates. Hulme and Mackenzie (1992) reviewing studies carried out in the field of cognitive psychology concluded that 'there is to date no good evidence for qualitative differences in psychological processes' (p.13) .

Time for synthesis?

Others have called for a synthesis of behavioural and cognitive approaches: Smith (1989, p.111) urged that practitioners should 'cease to maintain [this] often artificial distinction'.

Garner, Hinchcliffe and Sadow (1995, p.88) pointed out that the two approaches are not mutually exclusive: 'it is possible to be interactive when adopting a behavioural approach, and utilise behavioural principles when working within an interactive model'.

Collis and Lacey (1996, p.3) also supported the idea of combining the two approaches:

'much has been learned from behaviourism, both in terms of its rigours and its theory ... placing the two approaches side by side provides teachers with a powerful set of tools for enabling learning'.

Farrell too (1992) held that the behavioural/interactive dichotomy was a false one, that behavioural techniques could be used interactively, and interactive techniques used in a behavioural session. He (1992, p.145) maintained that objectives-based curricula 'were never intended to cover all areas of learning. Nor were children expected to work through tightly structured objectives-based teaching programmes all day'. Behavioural techniques, he suggested, are effective at the acquisition stage, interactive teaching helps the child to remember and generalise.

The boundaries between behavioural and cognitive approaches have, in any case, to some extent become blurred. Sugden (1989) pointed out that by 1989 some behavioural programmes were involving the child in decision-making, self-monitoring, goal setting and reinforcement; 'a long way from the original assumptions of the behavioural tradition' (p.21). Cognitive behaviour therapy as the name implies involves the extension of behaviour modification techniques to cognitive processes (e.g. Swaggart 1998).

The two approaches have long co-existed in mainstream education and continue to co-exist in both mainstream and special education; it is the relative emphases that have varied. Collis and Lacey (1996, p.2) pointed out that the language of special needs education is rooted in behaviourism, in the formulation of statements of special educational need and in the writing of individual education plans (IEPs). The Warnock Report (DES 1978 – see below, Section 2.3.5) adopted behavioural models, reflected in the statement of special educational needs, as a positive teaching approach and a way of focusing on individual needs rather than 'futile and stigmatizing efforts to remediate deficits' (Corbett and Norwich 1999, p.123). The Code of Practice (DfES 2001) specified the use of IEPs for pupils at all stages on the SEN register of a school, setting out steps towards a norm in terms of SMART (Specific, Manageable (or Measurable), Achievable, Relevant and Timed) targets.

Corbett and Norwich (2005) have pointed out that these principles, in particular the setting of measurable targets, have been extended to mainstream schools in moves by recent governments to raise educational standards. The use of IEPs and of 'SMART' targets has variously been seen as a means of ensuring accountability, as a bureaucratic

nightmare, as a constructive way of planning for individual needs or as reductionist and restrictive. Corbett and Norwich (1999) and Tilstone *et al* (2000) have suggested that these kind of targets may be suitable for certain areas of learning but less so for other areas, such as personal and social education or the fostering of creative and problem-solving skills. A feature of learning in ISCs and other centres of informal learning is that it is target-free; our previous research (Brooke 1994, Brooke and Solomon 1998) in the ISC where this study took place had shown it could foster creative, problem-solving skills in mainstream pupils and one of the aims of the study was to find out how students with SLD would respond to this environment.

2.3.4 The influence of the National Curriculum: vehicle for change or sidelining debate?

Despite the statement in the 1988 Education Reform Act that all pupils are entitled to a 'broad and balanced curriculum of which the National Curriculum forms a part', when the National Curriculum (NC) was introduced the original documents appeared to ignore pupils with severe learning difficulties. Special educators feared that their pupils would be further marginalised by its introduction (Tilstone 1991).

A vocal body of teachers felt that the entitlement to the NC should be claimed for all pupils, both as 'a step towards achieving social and legal rights for disabled children' (Aird 2001, p.2) and to provide opportunity for increased integration, in that all pupils would be following a shared curriculum (the integration/inclusion debate will be discussed later). Lewis (1991, p.1) endorsed this view of the NC as an entitlement '*which no child should be denied*' and as facilitating inclusion in providing a shared framework

but argued for the need to safeguard a broad and appropriate curriculum. A large proportion of special education publications of the 1990s focused on entitlement to, and implementation of, the NC for pupils with SEN (e.g. Ashdown, Carpenter and Bovair 1990, Bovair, Carpenter and Upton 1992, Carpenter Ashdown and Bovair 1996).

Grove and Peacey (1999, pp.83-84) described what they perceived as three categories of response to the NC by teachers in special schools:

- ‘seeking to provide complementary curricula’: maintaining previous ‘special’ curricula in addition to the NC;
- ‘redescription’: the re-labelling of what was already taking place;
- ‘subjects as contexts of experience’ – using subject areas as contexts for other learning and for meeting individual targets.

Babbage, Byers and Redding (1999, p.52) have suggested that more recent responses to the NC have been more sophisticated and that it has contributed in a practical way to a ‘paradigm shift’ in special education, forcing teachers to think about how they teach as they grapple with changes to what they teach.

Critiques of the entitlement stance

Concerns were expressed from the early 1990s (e.g. Byers 1994, Locke 1996) that preoccupation with achieving NC targets could squeeze out some of the vital work on more basic skills. Locke (1996) stressed the need to consider the social, physical, linguistic and cognitive skills that all children need to acquire before they can access the

NC. She pointed out that there is little point in teaching a child how to fill a jug of water and calling it science simply for the sake of ticking off a NC target.

Aird (2001, p.2) stated more categorically that 'the bulk of the NC was largely irrelevant and meaningless to the circumstances of many pupils with SLD/PMLD', maintaining that discussion of difficulties in engaging pupils should focus on the irrelevance of the curriculum rather than ways in which teachers could make pupils more active participants. He further suggested that special schools may have been driven to diluting or dropping excellent practice and adopting the NC by concerns about inspections and even school closure. He was sceptical too about the introduction of 'P-levels', which he described as a 'curious hybrid of developmental/ behaviourist/ academic criteria', designed to make the general curriculum accessible to those with the most severe difficulties, although, he claimed, 'pupils with profound and complex difficulties are notoriously poor consumers of generalised curricula', and are 'recognised as requiring a curriculum based on individual needs' (p.5). The question of whether or not there is a need for a different pedagogy for students with SEN will be taken up again in Section 2.3.6.

Sidelining debate?

Nind (2000) has pointed out that much of the special education literature of the 1990s was concerned with the curriculum content and access. She described vital debates concerning teaching methods as having been sidelined. This appears to have been true also for mainstream education with the NC placing the emphasis firmly on product rather than process (see for example Byers 1994). Rose (1998) also described pedagogy as a

vital element missing from the debate: 'many of the arguments which have surrounded the relevance, or otherwise, of the National Curriculum have focused upon content and have chosen to ignore the issues of learning and pedagogy' (p.30). Garner *et al* (1995) put it more strongly, already in the mid-1990s calling for renewed consideration of pedagogy in special education, following what they described as the 'major stumbling block in the late 1980s'. They argued that 'now that the impact of the National Curriculum is beginning to wear off, it is time for special educators to meet this challenge and continue to develop new approaches to teaching children with severe learning difficulties' (p.89). Considerations of teaching methods and pedagogy will be taken up again later.

Science for SEN in the National Curriculum

Responses of special educators to science in the newly introduced National Curriculum are of particular interest here, not only because a science centre was the setting for the research, but also because science, which had been considered, as Ritchie (1996) put it, an 'optional extra' in primary and special schools, suddenly became a core subject. Work that was already taking place in special schools, in particular the use of sensory rooms and sensory banks for those experiencing the most severe difficulties, was adapted to fit the original NC science modules: the 'redescription' of Grove and Peacey's (1999) categories. Longhorn (1993) proposed a 'sensory science curriculum' based on these modules and other works, such as *Science for All* (Jones and Skelton 1993), also provided a range of interesting activities and a useful progression but often relating these to NC attainment targets appeared somewhat contrived, the more so because these targets were so rapidly revised.

A number of authors (e.g. Howe 1991, Ritchie 1996) claimed particular advantages for including science in the curriculum for pupils with learning difficulties, in a way that related to Grove and Peacey's (1999) third category: 'subjects as contexts of experience'. Many of these advantages were linked to the methods commonly used in teaching science rather than to curriculum content however; for instance the fact that science is based on practical work, and that it lends itself to group work and therefore encourages the development of social skills;

Recent publications continue to reflect Grove and Peacey's (1999) categories: Davis (2001) has taken up and updated Longhorn's approach for students with profound and multiple learning difficulties (PMLD), relating opportunities for sensory experiences to NC modules, including science: using curriculum subjects as contexts for experience. Holden and Cooke (2005) have focused on making an unchanged secondary science curriculum more accessible to students with a range of SEN: suggestions for students with SLD include using visual supports, allowing more processing time, setting differentiated tasks and achievable targets and accepting a variety of recording methods. Briggs (2005) has provided practical strategies as part of an imaginative, whole school approach to inclusion in primary schools (discussed below) but does not include subject specific material.

2.3.5 Integration or inclusion?

The Warnock Report (DES 1978) represented something of a watershed in developments in special education, in moving away from the 'psycho-medical paradigm' (Skidmore 2004). Tilstone (1991, p.14) described it as 'a brave attempt to move away from categorization and the consequent stigma', although in so doing it reinforced aspects of the behavioural approach, in a way that remains very powerful (see above).

The report described a single population of children with a basic right to an education, some of whom (one in five it was estimated) would at some time during their education have 'special educational needs' in varying degrees. By stressing that the aims of education were the same for all children the Warnock Report had laid the basis for promoting the integration of children with special educational needs into ordinary schools. It also incorporated a move towards an 'interactive' view of learning difficulties as being 'outcomes of the interaction of child and environmental causal factors' (Norwich 1990 p.40).

The Warnock Report formalised the concept of integration much discussed in the literature of the 1980s and early 1990s; it described three types of integration: 'locational' - special provision on the same site as a mainstream provision - 'social' - children attending a special class or unit eating, playing, or otherwise 'consorting' with mainstream children - and 'functional' - children with special needs joining 'part-time or full-time the regular classes of the mainstream school and making a full contribution to the activities of the school. The assumption was that children should be educated in mainstream schools *unless* their parents did not agree, it was considered impossible for

the school to meet the child's needs, it was likely to hinder other children's needs being met, or was not compatible with efficient use of resources. The 2001 SEN and Disability Act recognises only two conditions under which children may be educated elsewhere than in mainstream schools: if this is incompatible with the wishes of the parents or with the efficient education of other children, placing the onus on schools and LEAs to 'make reasonable adjustments' to provide for students with SEN or disabilities.

Despite the 'interactive' view of disability incorporated in the Warnock Report the main thrust of integration was to fit pupils into an unchanged system (see for example Mittler 2000, Thomas and Loxley 2001); entitlement and access to the NC could be seen as part of this drive, permitting pupils with special needs to 'fit in'.

Inclusion: a new perspective?

The late 1980s and early 1990s saw a radical development of the 'interactive model' of SEN proposed in the Warnock Report and the beginning of a significant shift in thinking towards a view of learning difficulties, not as inherent within the learner but as a result of a mismatch between the learner and the learning opportunities (Booth 1992). This radically different way of seeing difficulties as located in contexts coincided with the development of the social model of disability (Oliver 1988) which argued that while impairment might be located within the individual, people were disabled by processes and structures in the society.

From an educational standpoint integration had meant the pupil, not the school, having to adapt, while inclusion is more generally understood as schools improving their capacity

to accommodate diversity, even radically reforming their systems (Booth, Ainscow and Dyson 1997, Florian 1998). For some this accommodation is seen as primarily organisational, for others the social dimension has been paramount. It is recognised (e.g. Clough 2000, Kellett and Nind 2003) that there is no neat consensus definition of inclusion and that this is contested ground.

The 'organisational paradigm' (Skidmore 2004) – the need to change school structures for inclusion (e.g. Booth *et al* 1997) - has gained increasing currency and this is reflected in more recent government publications. Skidmore (2004, p.15) noted that in the Revised Code of Practice (DfES 2001) there is recognition that difficulties in learning may be the result of deficiencies in the school rather than deficits of the child. He pointed out that the Code nevertheless retains the notion of 'a local norm of school organisation', in that a child is seen as having special needs if he or she requires provision which is 'additional to or otherwise different from this norm.' (p.15).

Another facet of educational inclusion relates to the social model of disability and incorporates a rejection of the 'normalisation' and 'denial of differentness' inherent in the concept of integration (Florian 1998, p.15): 'it is based on a value system that welcomes and celebrates diversity' (Mittler 2000, p.10). Allied to a rejection of 'normalisation' is the concept of participation contained in models of social inclusion (Booth *et al* 1997), an essential element of which is having a choice about when and whether to take part (Florian 1998 p.16).

Removing barriers? Inclusion versus school improvement

Recent government policy (SEN Strategy: Removing Barriers to Achievement 2004) emphasised the twin concepts of inclusion and celebration of difference. However, it has been noted that there is a tension 'between the pursuit of excellence (or improved 'effectiveness') in schools and the principle of equity (or greater 'inclusiveness')' (Skidmore 2004, p.23), and between inclusive practices and league tables (Corbett and Norwich 2005). Many schools feel caught between conflicting pressures (Corbett and Norwich 2005, Florian and Rouse 2005), yet Florian and Rouse (2005, p.153) suggest that for some schools 'policies and practices that support inclusion are emerging as the means by which they may be able to raise academic standards for all children'. They stress, however, that blame for the very real difficulties facing staff as well as students should not be transferred from the pupil to the school.

If it is possible for inclusive practice to result in improvement for all it seems likely that pedagogical issues will have a vital role to play, yet it is a dimension of the inclusion debate that had been little discussed until recently. This will be explored in the next section.

2.3.6 Pedagogy for SEN or for all?

The complexities of many aspects of the inclusion debate are beyond the scope of this study, which concerns the responses of students from a number of special provisions to a particular learning environment. However, the role of the learning environment and the approaches used there - questions of pedagogy - are central to the research and it is here

that it is hoped that it has a contribution to make in exploring a particular, and unusual, setting.

Giangreco (1997) listed the following as common features of schools where inclusive education is reported to be thriving: collaborative teamwork; shared framework; family involvement; general educator ownership; clear role relationship; effective use of support staff; meaningful IEPs; procedures for evaluating effectiveness. Florian (1998) described these findings as consistent with other research, which emphasises school structures and focuses on organisation rather than pedagogy. School organisation is likely to be essential to inclusion, but it is clearly not enough if teaching methods used in the classroom are not accessible to all. Corbett (2001, p.55) pointed out that 'so often inclusive education has been vilified because learners have been placed in a situation in which they are unable to learn effectively'. This may seem self-evident and yet Nind (2005, p.1) noted that very little of the inclusion literature focuses on curriculum and pedagogy in inclusive classrooms, that indeed there is a lack of emphasis on pedagogy in the UK educational literature in general.

Babbage *et al* (1999, p.45) suggested that the methods, or pedagogy, debate was beginning to be re-opened in the SEN literature 'now that the debate about access to the content of the curriculum has largely been resolved'. Corbett and Norwich (1999, p.115) also noted that 'interest in teaching and teaching methods has been renewed recently under the label of pedagogy'. They argued that concepts of effective teaching will need to take account of diversity: 'if we adopt and adapt the kind of inclusive language used in

the SEN Green Paper (DfEE 1997) *Excellence for All* we would say ‘pedagogy is for all’ (p.14).

Individualised learning

One response to the search for a pedagogy that benefits *all* learners has been the idea of individualised teaching and learning. The recent government SEN Strategy ‘*Removing Barriers to Achievement*’ (DfES 2004), emphasised the need for ‘personalised education’ for all and awareness of individual learning styles. Babbage et al (1999) have incorporated ideas about individual learning styles (Sternberg 1997, Riding and Rayner 1998, Read 1998) and multiple intelligences (Gardner 1983), discussed above, into a learner profile in which individual learner preferences in areas such as listening, reading, speaking, reasoning, remembering and so on are plotted on a continuum from ease/comfort to frustration/stress. It is designed to be a practical tool to be used as the basis for decisions about learning opportunities, not only within the student’s comfort zone but also in areas where they may be able to learn with support. Read (1998) also proposed teaching to individual learning styles as a means of promoting inclusion, using the double continua of cognitive and learning styles - wholist/analyst, verbalist/imager (Riding and Rayner 1998, Riding and Read 1996).

However, Mortimore (2003) and Tilstone *et al* (2000) recognised that such an approach presents practical difficulties and may not, they suggested, even be helpful: ‘matching every pupils’ learning objectives to his or her preferred learning style all the time is not possible (nor desirable as one general learning objective should be that pupils *learn to learn* in different ways)’ (Tilstone *et al* 2000, p.35 - original emphasis). Tilstone *et al*

(2000) emphasised the need for a responsive, rather than an individualised, curriculum, one which, if it is going to fully embrace difference, 'should be adapted to children's needs not vice versa' while taking 'serious account of educational diversity and heterogeneity of educational needs' (p.12). They maintained that providing a variety of ways of accessing skills, knowledge and understanding can be 'a useful tool for preventing difficulties in learning' (p.35). They give as an example the provision of pictures and symbols for a student with SLD who appears to have good verbal skills but in fact has poor understanding. Both Mortimore (2003) and Tilstone *et al* (2000) suggested the teaching of metacognitive skills as one way forward, while recognising that some of these strategies are easier to teach than others. Techniques cited again raise the question of how effective these would be for students with very little language. It has also been suggested that individualised teaching, even where it is feasible, is a return to the behavioural approach of individual teaching programmes previously common in special education, rather than a move forwards to true inclusion (Ainscow 1997).

Should pedagogy for students with SEN be different or more of the same?

By considering individual as opposed to group needs discussions of individualised learning have tended to side-step the question of whether students with special educational needs benefit most from a different type of pedagogy to their mainstream peers or simply from additional teaching of the same type.

Positions have been deeply divided, with some authors denying any need for different kinds of teaching and presenting evidence from research studies which fail to show

differences in learning characteristics between groups classified according to whether or not they are identified as having a learning difficulty (see Norwich and Lewis 2001 for a review). Others have pointed to research evidence that seemed to suggest between group differences, either according to supposed ability or specific types of learning difficulty: Brown *et al* (1983), reviewing a number of studies, suggested that the ability to transfer learning from one situation to another was a distinguishing feature between more and less able students; the 'weaker' students they concluded, needed more explicit instructions and could only transfer to very similar tasks. Mastropieri, Scruggs and Butcher (1997) following an investigation into students' responses to an inquiry learning task concluded that students with 'mild mental retardation' may have a need for more direct instruction; Read (1998, p.133) set out what he saw as the learning characteristics of the 'less able', including a 'universal dislike of working alone', although this raises the question of the environment in which his observations took place and whether these students' responses could have been due, at least in part, to insecurity about getting things wrong on their own. Wishart (2005) has suggested that students with Down syndrome tend to show unwillingness to take the initiative in their learning. However, Hart, Dixon, Drummond and McIntyre (2004) have written eloquently of the risk of self-fulfilling prophecy in ability labelling and it may be that we need to look more closely at the learning environments in which some of these students found themselves in order to avoid this trap; the difference in the responses of students in different learning situations turned out to be a very important consideration for this research.

Corbett and Norwich (1999, p.119) stressed that 'celebrating difference' should not mean denying the very real difficulties faced by students with SEN and noted that 'you cannot

rule out in principle that some pupils with significant difficulties in learning can share certain distinctive characteristics and might respond better to *specific* kinds of pedagogy' without due consideration of the evidence. Norwich and Lewis (2001) carried out a comprehensive review of recent literature on pedagogy for SEN. They noted 'a trend away from SEN-specific pedagogies' and a tendency to assume that 'what works *with most* pupils would also work for *all pupils*' (p.324 – original emphasis): a view of educational needs as common to all necessitating a pedagogy common to all. However, they also noted a lack of research to justify this trend. They found support for a 'unique differences' position, requiring individualised responses, from a number of SEN specialists, qualified in some cases by recognition that students with SEN may need more intense and focused teaching. There was little support or evidence for specific groups being taught in different ways throughout their school careers. Norwich and Lewis (2001) acknowledged 'a persistent sense that special education means special pedagogy' but noted that even where studies had suggested within-group differences they did not show that a need for distinctive teaching for these groups necessarily followed. Specialists in a number of SEN fields were specifically asked to reflect on the question of whether particular groups required specialized teaching (Lewis and Norwich 2005). Those working with groups relevant to this study – people with severe learning difficulties (Porter 2005) or with Down syndrome (Wishart 2005) - concluded that there was a lack of reliable research evidence for the efficacy of specific pedagogies for these groups.

Continua of pedagogic approaches

Norwich (1996) identified three kinds of educational need - individual, exceptional, and

common – requiring a range of responses. Building on this Corbett and Norwich (1999) proposed that a range of educational needs should be met by a corresponding range of pedagogies ‘common to all’, ‘specific to some’, and ‘individual’. Norwich and Lewis (2001) suggested that that we need to think in terms of ‘continua of teaching or pedagogic approaches,’ adapted to the varying needs of students at different times:

What has been missing in talk about continua of special needs and special provision has been the notion of *continua of teaching or pedagogic approaches*. The concept of a continuum implies that there are differences of degree, so by teaching continua we mean that the various strategies and procedures which make up teaching can be considered in terms of whether they are used more or less in practice. It is also important at this stage of the discussion to remember that some pupils with SEN might need more of common teaching approaches at some times, but some distinct kinds of teaching at other times.
(Norwich and Lewis 2001, p.325)

They suggested that some students may need more practice time to achieve skills, more examples to learn a concept or more error-free learning at different times. Approaches may look different at extremes on a continuum but need not, they maintained, be qualitatively different, suggesting they should be seen rather as high or low intensity variations. They gave the example of sensory learning, clearly indispensable for the deaf-blind at ‘high intensity’ that could be used for others at a different point on the continuum, i.e. ‘lower intensity’ (Lewis and Norwich 2005, p.217). Corbett & Norwich (1999) also gave an example of children with significant difficulties in phonological skills who might benefit from intensive phonological training for a limited period. This is very different to teaching a particular group of children (based on their perceived ability or learning difficulties) in a different way for the entire curriculum. The key to the idea of continua of pedagogic approaches is its flexibility; the possibility of using different

approaches at different times (of a student's life or in the same day), for different subjects or for different individuals.

Recent developments and research in pedagogy for SEN and for inclusion

In order to develop continua of pedagogic approaches it will be essential to know as much as possible about different approaches, and for whom and in what circumstances they may be most appropriate. Much of the recent literature that does discuss teaching strategies and approaches emphasises individualisation (see above), or student groupings and classroom organisation: 'there appears to be some agreement across the strands of the inclusion literature about the efficacy of a number of teaching strategies thought to promote inclusive practice. These include co-operative learning, peer-mediated instruction and collaborative teaching' (Florian and Rouse 2005 p. 156). More than two thirds of a recent publication on strategies and resources for teaching and learning in inclusive classrooms (Gardner 2002) is devoted to collaborative learning. There has been considerable discussion of learning styles (e.g. Babbage *et al* 1999) but in general little discussion of modality of presentation or type of sensory input except for students with PMLD (e.g. Davis 2001, see above). There is a tendency to take for granted that approaches for students with SEN will include active and visual learning (e.g. Babbage *et al* 1999) but little discussion of what this means in practice, particularly for those who find verbal/auditory input very difficult. Recommendations frequently focus on ensuring access to existing mainstream practice, for example the suggested use of pictures and symbols to supplement verbal material (Tilstone *et al* 2000, Holden and Cooke 2005).

Briggs (2005), on the other hand, provides more imaginative and practical suggestions for making the primary curriculum more accessible as part of a whole school approach, for example teaching some signs to all the pupils in a school. Briggs (2005) also provides a short section on the need for multi-sensory approaches, with practical advice on the provision of visual and kinaesthetic as well as auditory learning opportunities for all students, not just those with SEN, and even for making use of other senses, smell and taste, where appropriate.

Gersten, Baker and Lloyd (2000) noted a lack of research in recent years investigating the effects of innovative approaches in special education. A systematic review of research (Rix and Hall *et al*, in press) shows recent research to focus on verbal/written interactions, rarely on other modes. However it may be that this situation is beginning to change; renewed interest in pedagogy has led to some research into approaches that are not 'special' but are being used in innovative ways in special needs or inclusive education settings.

Corbett and Norwich (2005 p.27) have advocated what they term a connective pedagogy 'that connects with the individual learner and their own way of learning and that can connect them into the curriculum and the wider school community', a concept that is far removed from the 'dump and hope model' of integration where placement alone is the criterion for success' (Corbett 2001, p.58). Corbett and Norwich (2005) and Florian and Rouse (2005) see the role of the teacher as central in ensuring social inclusion for pupils who often experience significant barriers in this area, while noting (Corbett and Norwich 2005) that respect for individuals does not include forced social participation. Corbett

(2001) carried out a case study of a school where successful inclusion was taking place and found both pedagogy and organisational factors to be essential features but also an 'emphasis on listening to and valuing what children have to say' (p.59). Hart *et al* (2004) provide accounts of imaginative and innovative ways in which a number of practising teachers have developed approaches that avoid ability labelling and are truly inclusive; for example secondary history lessons based on a belief that the success of a lesson depends on teaching and learning experiences that are accessible to everyone, in a situation in which everyone feels emotionally safe, comfortable and positive and that they have achieved something worthwhile by the end of the lesson (p.138).

As long ago as 1994 Nind and Hewett showed how the use of an approach based on normal infant-caregiver interactions could radically improve the communication skills of people with very severe learning difficulties and the efficacy of Intensive Interaction has since been confirmed by a number of evaluative studies (Watson and Knight 1991, Watson and Fisher 1997, Kellett 2001). Kellett (2005) has explored how a change of emphasis and of modality in music lessons - focusing on listening rather than performance skills and using scaffolding techniques - greatly increased inclusion in these lessons.

Nevertheless studies of innovative approaches for SEN or inclusion, whether new approaches or the use of existing ones in a new way or for new groups, remain relatively rare. The present study constitutes an exploration of a particular learning environment (the ISC) and the particular pedagogy of this environment, for a particular group (students with SLD). Previous research in this ISC and research on learning in ISCs in

general have been detailed above but no studies have been published on the responses of students with SLD to ISC visits. It is hoped that in exploring a very different setting and approach this study has something to add to considerations of the range of options available to teachers and to Norwich and Lewis's (2001) 'continua' of approaches.

CHAPTER 3: METHODOLOGY AND METHODS

3.1 Introduction

The original impetus behind the present research was work carried out in the ISC with groups from mainstream schools (Brooke 1994, Brooke and Solomon 1996, Brooke and Solomon 1998). This work had suggested that this could be a highly effective learning environment for students designated as having moderate learning difficulties (MLD) and led to the desire to find out how students considered to have severe learning difficulties (SLD) would respond to this environment. The initial research question was therefore a very broad one: 'How do students with severe learning difficulties respond to visits to a small interactive science centre?'

A preliminary literature search had suggested that this was an area that had not previously been explored: studies relating to the use of different teaching methods for students with SLD have been discussed, as has research relating to interactive science centres (ISCs) as learning environments. The literature search has not to date revealed any studies of students with SLD working in an ISC or of the usefulness of this type of learning environment for this particular group.

The initial aim of this research was therefore descriptive but as the unusual nature of student responses became clear further questions emerged and the beginnings at least of explanations for what was happening were sought. Given the newness of the area, a

methodology based on, although not precisely following, grounded theory strategy (Glaser and Strauss 1967, Strauss and Corbin 1998) was considered most appropriate.

3.2 Rationale for the Approach

3.2.1 Choice of paradigm

Cohen, Manion and Morrison (2000) saw the aim of those working within interpretive paradigms as being to understand the subjective world of human experience while retaining the integrity of the phenomena under study, avoiding imposing external form and structure as far as possible. The aim of the present research was to explore the complexity of a particular learning situation that had not hitherto been studied and to understand it as fully as possible.

Dyson (1998 p 2) suggested that the 'paradigm dialogue' is of particular importance in the field of special educational needs (SEN), given the assumption of the positivist tradition that there is a reality 'out there' to be discovered and therefore by implication in the field of special educational needs that these are 'real', that the problem lies within the student rather than in the relationship between a particular student and a particular setting. The present research focused precisely on the relationship between a number of individuals and a particular setting. Vulliamy and Webb (1992) also pointed out that for a long time special educational needs research had been dominated by those trained in the discipline of psychology and in the positivist approach in both mainstream and special education. They noted that concerns had been increasingly expressed that experimental settings did not

reflect the realities of teaching and learning and that the results of quantitative studies of large samples had done little to influence practice. This has led to an increasing interest among educationalists in interpretive approaches and the use of qualitative or combined qualitative/quantitative methods.

Nevertheless, the use of interpretive approaches brings with it its own risks. Schwandt (1994, p.118) stated that 'the ... interpretivist believes that to understand the world of meaning one must interpret it' but inevitably this means a risk of misinterpretation. One means of validating the interpretations of the researcher is to check them against the participants' own interpretations. Strauss and Corbin see this as an important step in grounded theory:

Interpretations *must* include the perspectives and voices of the people whom we study .. Those who use grounded theory procedures ... accept responsibility for their interpretive roles. They do not believe it sufficient merely to report ... (they) assume the further responsibility of interpreting what is observed, heard or read. (Strauss and Corbin 1994, p.274)

This raised particular issues for the present research as the participants were not able themselves to comment on interpretations placed on their actions by the researcher. This will be discussed in detail in the sections on ethics and validity.

3.2.2 Choice of methodology

The methodology chosen does not fit neatly into one particular established approach but rather follows Denzin and Lincoln's (1994) view of the qualitative researcher as a '*bricoleur*' (one who makes creative use of what is to hand to get the job done), using and

adapting the tools best suited to the questions being asked. Cohen et al (2000) similarly urge that research design should be governed by 'fitness for purpose'.

Grounded theory

The over-arching methodology used drew on grounded theory (Glaser and Strauss 1967, Strauss and Corbin 1998) but did not precisely follow all its procedures. Indeed Strauss and Corbin (1998) recommend that these should not be followed as a recipe, or applied in rote fashion, but rather that the researcher should treat them as 'items on a smorgasbord table from which they can choose, reject and ignore' (pp.8-9). In its broad outline, grounded theory was the methodology of choice in that the area being explored was apparently a new one and in that the aim, although initially descriptive, was to begin to form tentative explanatory propositions and to explore these.

Commonalities with and divergences from grounded theory

Strauss and Corbin (1998) see one of the major differences between grounded theory and other approaches to qualitative research as 'its emphasis on theory development'. The aim was not to produce and verify fully-fledged theory as Glaser and Strauss originally conceived this method (Glaser and Strauss 1967, Strauss and Corbin 1998) but rather to go a little way along this path, in attempting initially to describe and then to find possible explanations and hypotheses to answer some of the questions that arose as the research proceeded.

Fundamental to the concept of grounded theory is the idea that 'a researcher does not begin [the] project with a preconceived theory in mind... Rather, the researcher begins with an area of study and allows the theory to emerge from the data' (Strauss and Corbin 1998, p.12). However, Glaser and Strauss (1967) recognised the need for what they termed 'theoretical sensitivity', the need to be aware of what has gone before - of the literature and of previous studies - but not to be stifled or strait-jacketed by it:

Of course the researcher does not approach reality as a tabula rasa. He must have a perspective that will help him see relevant data and abstract significant categories from his scrutiny of the data. (Glaser and Strauss 1967, p.3)

Or, as Strauss and Corbin (1998, p.47), put it 'in short there is a difference between an open mind and an empty head'. In the present case, as the researcher, I was sensitized by, and the research questions were informed by, previous research and previous reading, but beyond this there were no pre-conceived ideas of what to expect. Glaser and Strauss (1967) see reading as an ongoing process throughout the research, neither exclusively preceding nor following it, and this too was the case here.

A conscious attempt was made to avoid any pre-conceptions in data analysis as well as data gathering, to avoid the 'forcing of 'round data' into 'square categories" (Glaser & Strauss 1967, p.37): no *a priori* coding system was used; codes and categories were derived from the data using the principle of emergent fit, modifying categories to fit the data rather than fitting data into pre-existing categories (Taber 2000). A form of 'constant comparison' (Glaser and Strauss 1967, Strauss and Corbin 1998) was used in this process, comparing one section of data to another but also comparing data with what was previously known or learnt during the research. Constant comparison ensures that data that does not fit emerging

categories is not ignored, and helps the researcher avoid the temptation to choose examples to fit a pre-formed theory (Glaser & Strauss 1967). It also encourages the search for negative cases. It is a very different process to the comparison of matched groups in positivist research: 'Group comparisons ... are made by comparing diverse or similar evidence indicating the same conceptual categories and properties' (Glaser & Strauss 1967, p.49). Glaser and Strauss (1967) maintain that it is not possible to pre-plan the set of groups that will be studied as this will be determined by the ongoing analysis (the process they call 'theoretical sampling'). They maintain that it is even possible to create groups for the purpose of comparison to answer specific questions. The extent to which 'theoretical sampling' was used in the present study will be detailed in the research design.

The main differences between the methods used in the present research and those of grounded theory lie in the coding and questioning techniques that did not precisely follow the prescriptions of grounded theory; the micro-analysis recommended by Glaser and Strauss (1967) and Strauss and Corbin (1998) as part of the initial coding process appears more suited to interview material which can be coded at points word by word. 'Open' coding – the attribution of detailed codes to all observed behaviour - and 'theoretical' coding, using more abstract categories, were used in broad outline but not carried out precisely as laid down by Glaser (1978) or Strauss and Corbin (1998). The way in which this was done is outlined in the research design. Questioning as well as comparison was used to derive and test emerging categories but again not in the very explicit and particular way described by Glaser and Strauss (1967), rather implicit questioning was used corresponding to Strauss & Corbin's (1998) broad categories of sensitizing questions -

'what is going on here?' - and theorizing questions - 'how do these categories relate to each other?'

An essential component of the grounded theory process is its iterative nature and the design of this research was conceived in this way, with ongoing analysis informing each stage of data collection. It also combined inductive and deductive processes: the formation of provisional hypotheses or propositions and the beginnings of verification of these (Strauss and Corbin 1994). Decisions about the later stages of data collection approximated to the procedure that Glaser and Strauss (1967) called 'theoretical sampling', that is decisions about what data to gather were informed by ongoing data analysis and the need to answer specific questions. Theoretical samples are very different to statistical or random samples; they are used to add information to or test a developing theory by looking for answers to specific questions or searching for negative instances.

Glaser and Strauss (1967) recommended the use of 'slices of data', a technique resembling some forms of triangulation, which aims to increase validity by providing different viewpoints but also to answer specific questions. An example of this in the present research was the semi-structured interviews carried out with the teachers. A further important concept used in grounded theory is that of 'theoretical saturation', 'where further data collection and analysis does not significantly change the model being developed' (Glaser & Strauss 1998, p. 64). Glaser and Strauss recognised that it may be difficult to be certain when this point is reached but it became clear in the present research that studying the responses of a sixth student in full detail was adding little new information (the original

intention had been to study six students in detail, three more for comparison, this was revised to five major participants and four minor participants).

Use of case study methodology

Grounded theory is a strategy for ensuring that conclusions are grounded in data, it does not specify the precise nature of that data nor the means of collecting them: 'the grounded theory approach is intended to generate models that can potentially be tested by traditional logico-deductive techniques. However, the starting point for constructing such models is the detailed study of individual cases' (Taber 2000, p.470). Techniques used in the initial, descriptive phase of the present research share many characteristics with case study methodology; in particular the aim to describe the complexities of a real-life situation - visits by particular individuals to a particular ISC - and 'to retain the holistic and meaningful characteristics' of this situation (Yin 1994, p.14).

A single definition of case study has proved elusive (Bassey 1999) but overarching definitions have been suggested that are applicable to the present study: Sturman (1994, p.61) regarded 'case study' as 'a generic term for the investigation of an individual, group or phenomenon', Yin (1994, p.1) defined it as 'an empirical enquiry that investigates a contemporary phenomenon within its real-life context'. It is true that the 'phenomenon' studied in the present research was to some extent created by the researcher in that groups from educational provisions for students with SLD were invited to visit the science centre. Beyond this, however, there was little difference between their visits and any other visits

except that the numbers were smaller and initial introduction to the activities was predominantly non-verbal (this would also have been the case for younger mainstream groups). As the researcher, my aim was to influence the situation as little as possible outside of my normal role of facilitator in the ISC.

Punch (2005) noted that a 'case' may be 'an individual, a role, a small group, an organization, a community or a nation, a decision, a policy, a process, an incident or an event'. In the present study neither the ISC in its entirety nor the individual students in all aspects of their lives were studied; the 'case' could be considered to be the individual students in the context of the ISC. Further data were gathered to illuminate the case: interviews with the participants' teachers, the filming of sessions in the students' usual educational settings and the study of school or college records. Hence the bounded nature of the study focus on responses to the ISC involved conceptual rather than physical boundaries. However, the present research design diverges from usual case study design in that I went beyond natural real-life contexts. I, as the researcher, also created a number of somewhat artificial situations, in order to explore particular questions arising from the data (this in keeping with the idea of 'theoretical sampling' in grounded theory: follow-up visits were designed specifically to explore recall and transfer as well as to test the question of whether responses in the ISC related to the fact that it was a visit out of school.

Yin (1993) distinguished between descriptive, exploratory and explanatory case studies:

An exploratory case study...is aimed at defining the questions and hypotheses of a subsequent (not necessarily case) study ... A descriptive case study presents a complete description of a phenomenon within its context. An explanatory case study presents data bearing on cause-effect relationships ... (Yin 1993, p.5)

The present study contains elements of all three: the initial aim was description of a situation that had not hitherto been studied, but the study also aimed to define questions and hypotheses, through the use of grounded theory techniques, which were further examined in an explanatory phase.

The particular strength of case study methodology is that it is 'strong in reality', preserving the integrity and complexity of a real life situation (Robson 1993, Cohen *et al* 2000)).

However this emphasis on the particular has also been perceived as a weakness; case studies have been criticised as producing results that may not be generalisable except where readers/researchers see an application (Cohen *et al* 2000, Yin 1994). A number of authors (e.g. Stenhouse 1988) have maintained that generalisation is not an essential outcome of a case study. Others (Yin 1994, Stake 1995, Tripp 1985) have argued that, while it is not possible to generalise from a single case to a population, it is possible to generalise in other important ways, for example to theory (Yin 1994) or to the reader's experience (Stake 1995, Tripp 1985). Schofield (1993) argued that it is also possible to generalise 'to what could be', to study what is possible given the right circumstances, rather than what is typical and in the present instance one aim was to find out what was possible for these students in this setting.

A further criticism of case study methodology is that it is open to selectivity and bias unless sufficient safeguards are put in place (Cohen *et al* 2000); In a study designed to 'shed light on what could be' (Schofield 1993, p.105) some degree of selectivity is built into the design and in the present instance this affected selection of participants (see Section 3.5). Nevertheless it was important to avoid selectivity in other ways, for example selection of material to fit a particular hypothesis. These issues of generalisability and bias will be taken up again in relation to the present research in Sections 3.6 and 3.7.

Data management

The management of large amounts of data is an issue in most naturalistic research. As Yin (1994) noted, it is not enough to describe anything and everything, even in a case study concerned with the 'rich and vivid description of events' (Cohen and Manion 2000). The aim of the descriptive phase of this study was rich description, to give as complete a picture as possible of the students' responses but even in doing this a certain degree of selection and therefore a first layer of analysis is inevitable. It was the aim of the research to go beyond description and to look for possible explanations for what was observed; for this grounded theory techniques were used but also a process recommended by Huberman and Miles (1994) of moving between data collection, data reduction and display, conclusion drawing and verifying. The process (summarised in Figure 4) dovetails with the grounded theory cycles on which it draws, in a way that 'can help a researcher work from field notes to some conceptual understanding of the processes being studied.' (Denzin and Lincoln 1994, p.356).

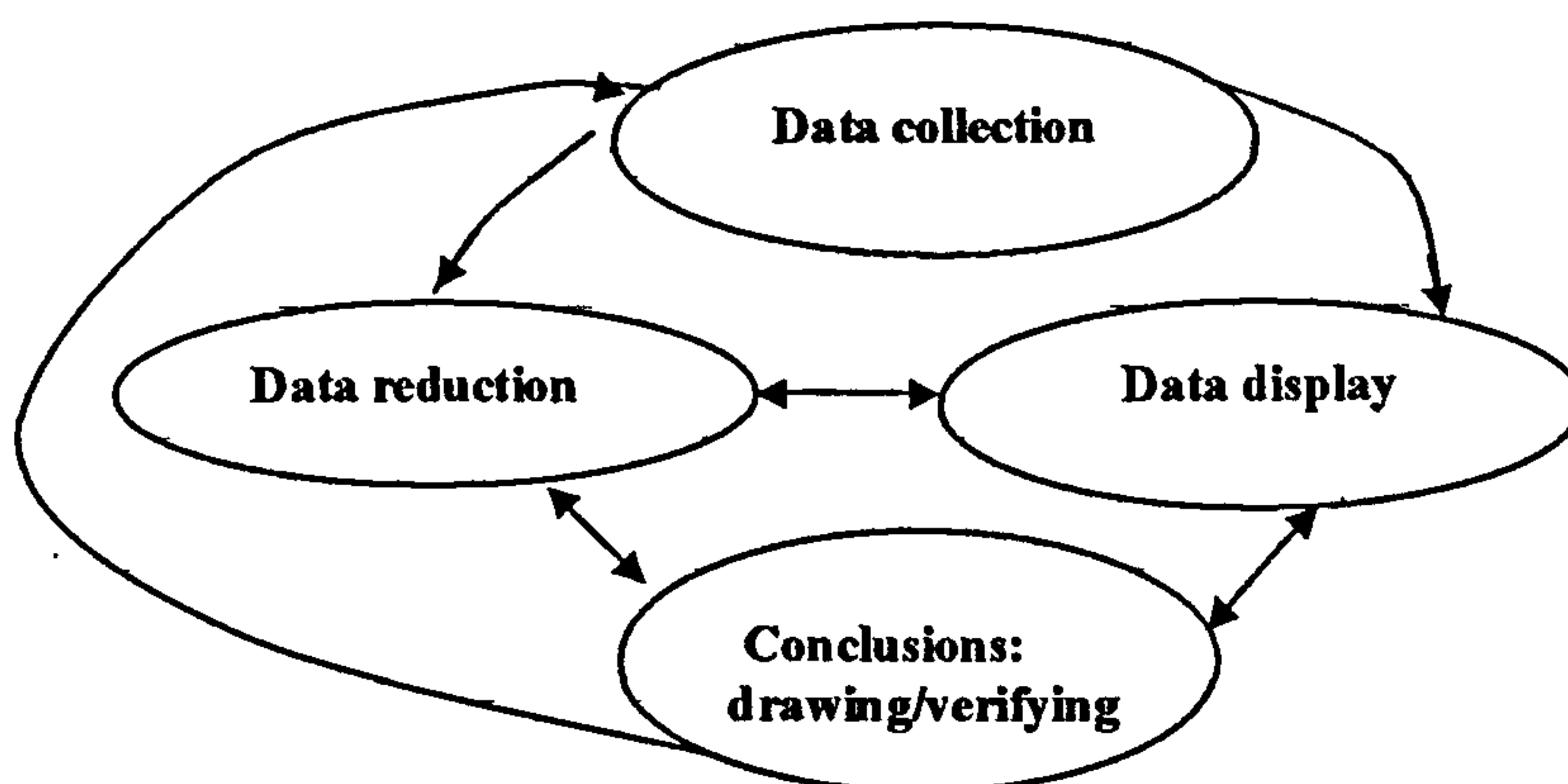


Figure 4: Components of Data Analysis: Interactive Model (after Huberman and Miles 1994 p.429)

The way in which these components of data analysis were used in conjunction with grounded theory cycles will be detailed in Section 3.5.

3.3 Ethical Considerations

This study raised not only the ethical considerations common to all research but particular issues relating to the fact that the participants all experienced severe learning difficulties. Clough and Barton (1995) urged researchers to consider the extent to which their research is carried out *with*, or at least *for*, rather than *on* the researched. In considering the question 'Who is this work for?' (Barton 1998), it is clear that I, as the researcher, stand to benefit as it is to be submitted as a PhD thesis. However, it is sincerely hoped that the research will also benefit students with SLD and their teachers (and indeed mainstream students and teachers) by contributing to wider debates surrounding teaching methods and learning

environments, and to the related question of inclusion, by showing how one group of students responded to this type of learning environment.

3.3.1 Informed consent

Kellett and Nind (2001) noted that it may not always be possible to ensure that people with learning disabilities participating in a research project are doing so with fully informed consent but that it is possible to work with a network of those closest to the participants, who would be aware for example if they were at all distressed or uncomfortable. I drafted a letter which was approved by supervisors and by the headteacher of one of the schools in the study. This letter explained the identity of the researcher and the design and purpose of study and was sent to the parents of all students in groups visiting the science centre for the study, not only those chosen as participants. A verbal explanation was given to students in simpler terms by me and by their teachers. Written parental consent was obtained for all participants.

Staff who knew the students well were present at all sessions and students were told that it was up to them what they did at the ISC, leaving them free to opt out of activities if they wished to; Karen, for instance, opted to continue an art lesson rather than come to a follow-up session in school, then changed her mind. The aim throughout was to listen to and observe the students, to be sensitive to their responses; Corbett (1998, p.55) uses the term 'imaginative listening' but in this case 'imaginative observation' might be more appropriate. The overwhelming impression was that the students enjoyed the sessions and felt free to make independent decisions about whether and how to participate.

3.3.2 Anonymity

Names have been changed and information removed that would make it possible to identify individuals or individual schools. Although permission was granted to use any photographs included in the thesis (see below), these have been blurred to further protect identities.

3.3.3 Use of photographs and video material

Permission was obtained at all stages from parents for photography and filming, including ongoing permission for use in in-service training sessions for teachers. It was made clear verbally, via the schools or college, that this could be withdrawn at any time. Those operating the video cameras were sensitive to the students' responses and filming would have been stopped if they had shown any reluctance to be filmed but in fact this was never the case. Renewed permission was sought to use video footage or photographs for any other purpose (for example for a presentation to the British Educational Research Association New Researchers' Conference).

3.3.4 Ownership of data

Videos were made available to schools and parents if they wished to see them, with the understanding that participants could withdraw if they or their families were not happy for them to continue having seen the videos (none did so). The use of video and photographic material raises the issue of ownership, and therefore storage, of this data, both during the research and especially after it has been completed: whether it belongs to the participants and therefore should be returned to them, or to the researcher, or whether it should simply

be destroyed and belong to no one once the research is finished. A compromise similar to that described by Kellett and Nind (2001) was arrived at regarding storage of data, in which the researcher acted as 'banker' or unofficial archivist of video data: storing it safely and making it available if participants wished to view it, balancing the rights of participants against the desire to protect data that could be valuable in future studies.

3.4 Research Questions and Hypotheses Arising from the Data

In order to present the questions and hypotheses clearly it is necessary at this point to anticipate some aspects of the research in order to present what was in fact a cyclical process in a linear fashion. The research comprised two main phases: a first, descriptive or exploratory phase from which questions and hypotheses emerged and a second, explanatory phase, which sought to explore the emerging hypotheses and possible explanations for the observed responses of this small group of students. The main research question was a broad one in accordance with grounded theory principles (Glaser and Strauss 1967, Strauss and Corbin 1998). As the research progressed subsidiary questions and hypotheses emerged from the data; the following is a recapitulation of the way in which these arose.

3.4.1 Research questions relating to the descriptive/exploratory phase

The first, descriptive stage of the research began, then, with the initial broad question:

- **How do students with severe learning difficulties respond to visits to a small interactive science centre?**

In our previous research in the ISC (Brooke and Solomon 1996, Brooke 1994) we had used interview techniques, as well as whole group discussion, to investigate mainstream pupils' understanding of the concepts involved, their recall of what happened there and to some extent their ability to use this understanding and recall to solve new, hypothetical, problems. It was evident after the first of the preliminary studies for the present research (and confirmed by subsequent sessions) that interviews, even where supplemented with signing, mime and demonstration, would be unlikely to give a full picture of these students' understanding, recall and ability to transfer what they had done at the ISC to a slightly different situation. I therefore introduced follow-up sessions in which activities similar to, but not the same as, those at the ISC were taken to students' usual educational settings (school or college). Some whole group discussion sessions were retained, although these proved to be more useful in showing a contrast between students' responses in language-based and in active sessions than in adding to the picture of students' understanding.

Informal discussions with the participants' teachers during the preliminary stage of the research suggested they were witnessing something unusual for these students, particularly with regard to their concentration and involvement levels. The teachers seemed to feel that this contrasted with behaviour in their usual educational settings. One teacher, indeed, remarked during a visit to the ISC that the students in her group had very short attention spans, adding '*except at the ISC of course*' (field notes). This intriguing 'of course' added to the desire to look more closely at the students' responses in their usual educational settings and permission was sought, and granted, to incorporate filming of sessions in

school or college into the research design. The sessions were not chosen as representative, filming involved whatever was going on that day, although semi-structured interviews with the participants' teachers confirmed that the sessions and the students' responses to them were not out of the ordinary. They were designed as 'theoretical sampling' (Strauss and Corbin 1998) to provide a better understanding of the main context of the research, not as a comparative study in a positivist sense.

One suggestion put forward by teachers for the differences observed in the students' responses between school or college and the ISC was that this could be due to the novelty of the visit. Follow-up sessions also provided a means of investigating this possibility (once again, theoretical sampling). This data gathering outside of the ISC was designed to answer two further overarching questions:

- **How did these students respond to activities similar to those at the ISC carried out in their usual settings two to six weeks after a visit to the ISC?**
- **How did these students respond to a number of their usual sessions in school or college?**

Data gathered from all three types of session - ISC visits, follow-up sessions in school or college and ordinary school/college sessions - were used to explore more detailed questions and hypotheses as they emerged. These related to a number of areas that previous research,

ongoing review of the literature, informal discussion with staff and open coding of video material from the second of the preliminary studies had suggested as important:

Concentration and engagement with activities

Teachers in the study had commented from the outset on the high degree of concentration and engagement with the activities shown by their students and this was confirmed by open coding, leading to a number of subsidiary questions, focusing initially on the ISC visits:

- **Were these students actively engaged during visits to the ISC?**

Open coding had suggested not only high levels of engagement but a variety of ways in which students engaged with the activities. Further questions were posed relating to all sessions:

- **What types of engagement with activities could be observed?**
- **In what proportions?**

Within these different types of engaged activity, an area of particular interest was that of investigation or exploration; our previous research (Brooke and Solomon 1996, 1998) had shown students moving from play to exploration with curiosity as a powerful catalyst and I wanted to look more closely at whether these students showed similar responses, leading to the further question:

- **What preceded exploration or investigation?**

Teachers in the study had suggested a contrast in engagement levels between the ISC and school or college, and at first glance this seemed to be the case. However, there were times during ISC visits or follow-up sessions where engagement was also clearly reduced and it seemed important to look more closely at the following question:

- **Under what circumstances were these students most actively engaged in any of the sessions observed?**

Interactions with other people

School staff had remarked on a high level of communication and collaboration between students during the visit for the first preliminary study. Further observation suggested the picture to be more complex and led to another descriptive question:

- **How do these students respond to other people during visits to the ISC?**

Independence

An aspect of the participants' interactions with other people that assumed increasing importance for the research was the extent of their independence. Informal discussion, reinforced subsequently by semi-structured interviews with the teachers, as well as the

literature, had suggested that these students might find it difficult to take independent initiative. Initial observation in the ISC had suggested that this was very far from the case, leading to the further question:

- **To what extent do these students take independent initiative in the different sessions observed?**

Understanding, recall and transfer

Questions of recall and transfer of learning have been the focus of a considerable body of research in ISCs detailed in the literature review. Generalisation of learning from one situation to another has also been an important issue in the methods debate in special education, a powerful criticism of behavioural approaches being that they did not encourage learning that was readily transferred from one situation to another. Our previous research with mainstream groups in the ISC (Brooke 1994, Brooke and Solomon 1996, 1998) not only showed visits to be memorable but also that many students were able to use what was recalled to solve hypothetical problems. This was not the main focus of this research and it was not possible within the context of this study to go very far along this road, nevertheless it seemed important to ask the following questions:

- **What evidence is there of these students' understanding of any of the concepts involved in activities at the ISC during a visit?**

- **What evidence is there that these students recalled what they had done during the visit to the ISC?**
- **What evidence is there that these students were able transfer what had been learnt at the ISC to a slightly different situation?**

3.4.2 Research questions and hypotheses relating to the explanatory phase of the research

This second phase of the research set out to look in more detail at some of the questions arising from the first phase and to explore some possible explanations for what had been observed. One question stood out following the descriptive phase:

- **Why were these students' responses so different in different situations?**

And within this:

- **What led to such high levels of independent, engaged activity in certain situations?**

Evolving hypotheses

Two main propositions or hypotheses arising from the data and the descriptive phase of the study were explored: these related to the environment itself and within this to the students' interactions with other people. The way in which these hypotheses evolved and were revised is detailed in Chapter 5.

3.5 The Research Design

3.5.1 Summary of the design

The research design was iterative, in accordance with grounded theory principles, comprising successive cycles of data collection and analysis, each stage informing decisions about the following stage and moving between data collection, data reduction and display and conclusion drawing and verifying (Huberman and Miles 1994). Figure 5 gives a summary of the design, the correspondence of the design to grounded theory cycles is set out in Figure 6.

Phase 1 - Exploratory/Descriptive				Phase 2 - Explanatory
Initial question				
Cycle 1 – preliminary study 1	Cycle 2 – preliminary study 2	Cycle 3	Cycle 4	Cycle 5
Preliminary stages of data collection 1: Initial visit to ISC by Special School group Close observation, field notes, still photography	Preliminary stages of data collection 2: Two further visits to ISC by groups from educational provisions designated as being for students with SLD (a group from an FE college and a special school class on a mainstream secondary site). Introduction of follow-up sessions Video recording	Main data collection Y1 Video recording of: - session in students' usual educational setting - ISC visit - Follow-up session For each of 3 groups from primary, secondary and FE settings designated as being for students with SLD Study of school/college records for 3 students selected from each group	Main data collection Y2 As for year 1 – video recording of 3 sessions (school/college, ISC, follow-up) for each of the 3 groups – focusing on the 9 students selected in Y1 Semi-structured interviews with the teachers of the 3 groups using videos to stimulate recall	Re-interrogation of data
Formation of subsidiary questions -> decisions concerning theoretical sampling Ongoing literature review	Analysis stage 1 Open coding of video material -> further questions -> decisions regarding main stages of data collection Ongoing literature review	Analysis stage 2 Theoretical coding of video material Creation of colour-coded charts -> further questions Ongoing literature review	Analysis stage 3 Theoretical coding as for Y1 Colour-coded charts Quantitative analysis -> bar graphs 1 st sequential analysis -> further questions + hypotheses Ongoing literature review	Analysis stage 4 Evolving hypotheses, moving from exploration to explanation 2 nd sequential analysis Ongoing literature review

Figure 5: Summary of the research design

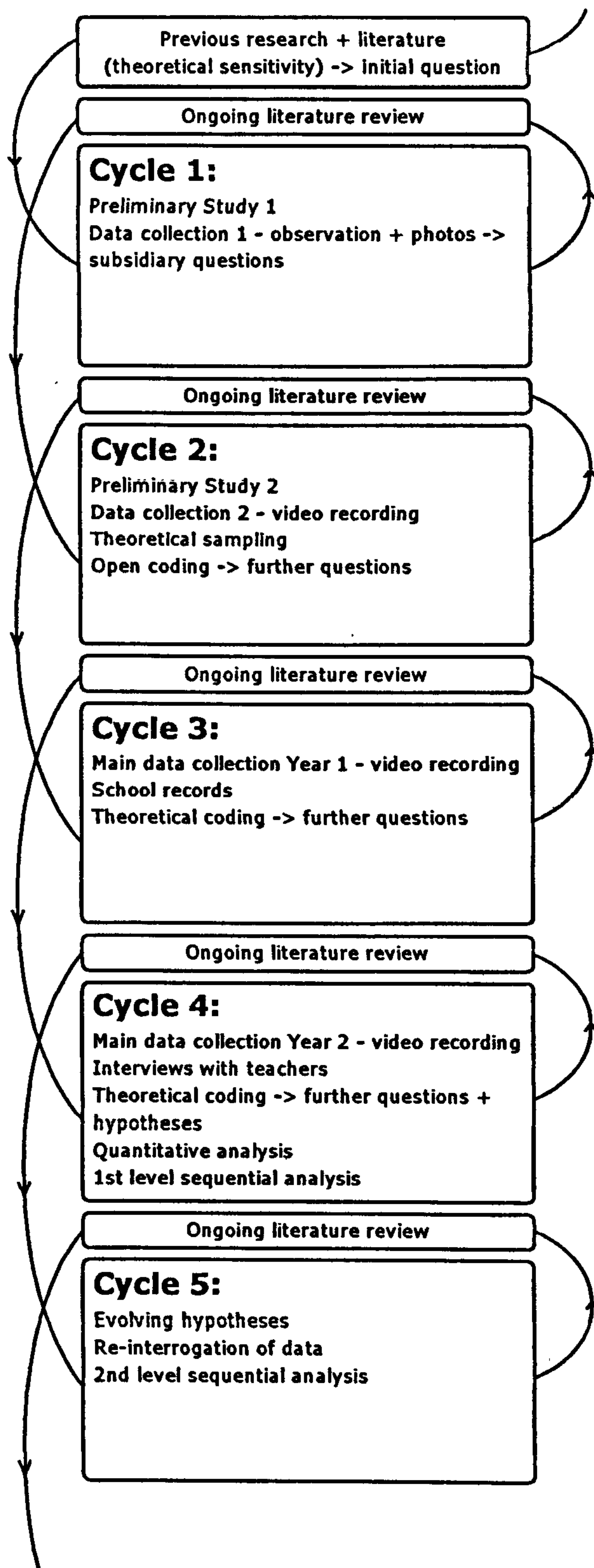


Figure 6: The research design showing grounded theory cycles.

3.5.2 The research design: descriptive/exploratory phase

Cycles 1 and 2 (preliminary studies)

The preliminary studies were designed to begin to explore the initial broad question: 'How do students with severe learning difficulties respond to visits to a small interactive science centre?' and suggest questions and directions for the next cycles; they were also used to explore observation methods. In the first preliminary study a group from a local special school was invited to visit the ISC and close observation and note-taking were supplemented by still photography. However, I felt that these methods did not provide a complete enough picture, especially as I was also involved in running and facilitating the session (see Introduction) and that still photography carried with it too high a risk of selectivity; I therefore decided to trial video recording in the second preliminary study. This method was retained for the final study (see below for a discussion of the advantages and disadvantages of this method).

During the first of the preliminary studies it also became clear that interview techniques used in previous research in the ISC (Brooke 1994) would not be adequate, given the students' communication difficulties, to give a full picture of their understanding, recall and ability to transfer what was recalled to a slightly different situation. This led to the decision to trial the use of follow-up sessions in the second of the preliminary studies to answer specific questions (theoretical sampling in grounded theory terms). Activities similar to, but not the same as, those in the ISC were taken into school or college in order to gain some insight into students' recall of the visit to the ISC and their ability to use what

they had done there to carry out slightly different activities in a different setting. This was also designed to give information about the extent to which behaviour in the ISC could be attributed to the novelty of a trip out of school.

The first stage of data analysis comprised initial, open, coding of video material from the second preliminary study. Initial stages of data collection, informal discussion with teachers accompanying groups and open coding led to subsidiary questions as outlined above; in particular discussion with teachers had suggested that they were witnessing something unusual at the ISC, leading to the question of how the students responded in their usual educational settings and the decision to further extend data collection to these settings. Permission was given to film ordinary school/college sessions and the typicality or otherwise of student behaviour during these was discussed with teachers in semi-structured interviews (see below).

Cycles 3 and 4

The later cycles of the study focused on visits to the ISC by groups of students from three different educational provisions, all designated as being for students with SLD: these were a special school class on a mainstream primary school site, the special school class on a mainstream secondary school site that had participated in the second preliminary study and a special class from a college of further education. For each of the three groups video recordings were made of three sessions: one in school or college prior to the visit to the ISC, the visit itself, and a follow-up session. This was repeated the following academic

year, so six sessions were filmed for each group in all. Two students were selected from each group for detailed study and one more from each to be studied in lesser detail (nine participants in all). Several of the students selected (Gemma, Richard, Karen, Bill and Jackie) had also taken part in the second of the preliminary studies, so in fact visited the ISC three years running. The aim was not to look at development in the students' responses over this period as it was felt that too many other factors would be involved, including maturation; this repetition of sessions did, however, give an indication of whether what was observed on the first occasion was a 'one off', unique to that occasion, and of whether students remembered the activities over a longer period. Most of all it provided a very large volume of data against which to verify categories, test emerging propositions and move towards theoretical saturation. All video material was transcribed in full.

I was given access to school or college records for the nine participants and semi-structured interviews with the teachers of these students were also carried out during this phase of the research. It was felt that these interviews would be important for a number of reasons: firstly to ascertain to what extent the teachers felt behaviour observed and filmed in the ISC or in school/college on a particular day was typical or atypical and to provide a different standpoint for the purposes of triangulation. The interviews also gave some insight into the teachers' perceptions of their pupils' difficulties and needs and what they saw as the best way of meeting these.

During Cycles 3 and 4 'theoretical coding' relating to levels and types of engagement with activities was used to code all video material, including re-coding of the video material

from the second preliminary study for students in the main study. These codes were used to show continuous 'state' sequences along a timeline. Each type of behaviour was colour coded thus making it possible to produce colour charts of each session giving an at-a-glance picture of each session in terms of students' levels and types of engagement and how these unfolded in time and changed during a session (see Appendix V). These charts also permitted a form of sequential analysis (Bakeman and Gottman 1997) designed to answer specific questions; in Cycle 4 a first piece of sequential analysis was used to examine the question of what led up to investigation or exploration. A second piece of sequential analysis was used in the explanatory phase. A further dimension was provided by small-scale quantitative analysis: the proportion of time spent in each type of engagement in the different sessions and parts of sessions was calculated and bar graphs produced to show this visually and enable eye-balling of the data. Further questions and hypotheses for the explanatory phase were derived from these analyses.

3.5.3 The research design: explanatory phase

This phase of the research was designed to explore questions and initial hypotheses arising from the descriptive/exploratory phase as set out above. Re-interrogation of the video data and re-examination of the colour charts and bar graphs made it possible to look more closely at a number of aspects and a second level of sequential analysis was used to explore the effect of interactions with other people. This explanatory phase also involved re-examination of the literature in relation to these questions and hypotheses. The hypotheses

were revised during this phase, emphasising the importance of the search for negative instances and alternative explanations.

3.5.4 Selection of participants

The initial aim was to select and pre-judge as little as possible in accordance with grounded theory principles; therefore during the first visit to the ISC for each group in Cycle 3 (first stage of main data collection), the person filming (who was not the researcher – see below) was deliberately given very little guidance about who or what to focus on. From the video of the first session, two students from each group were selected on the basis that they had made interesting use of the activities and thus might indicate ‘what may be or what could be’ in this situation (Schofield 1993). They were not necessarily atypical as they were seen by staff as being in the middle ability range for the group and by also gathering data on a wider range of students (see below) their typicality could in some way be judged. The participants selected for focusing in on, then, were not the most articulate, whose difficulties were often hard to distinguish from students designated as having MLD, nor were their difficulties within the PMLD range. All those selected for the main group (six students) had limited language and as it happened the majority of those chosen had Down syndrome. In order to avoid studying only those for whom it was most successful (in grounded theory terms, ‘theoretical sampling’, and the ‘search for negative instances’), one additional student was selected in each group for some smaller scale but nevertheless detailed observation who had more severe learning difficulties (two out of these three did not have Down syndrome) or who had made least use of the ISC in their groups. On

subsequent visits the camera operator(s) were asked to focus on the three chosen students in each group. In the end full analysis was carried out on data relating to only five of the six main participants because the sheer volume of data had become unwieldy and it was not felt that the sixth added significantly to the findings ('theoretical saturation'). This student was included with the comparison group.

3.5.5 Data collection

The stages of data collection are summarised above in Figure 5.

ISC sessions

Filming lasted for the whole of each visit (approximately one hour) and as much as possible of the session was recorded for each student, although clearly this could not be the entire visit for any one student as a maximum of two cameras were used.

School/college sessions

Recording of school or college sessions prior to visits involved filming whatever lesson was going on at the time, for three quarters of an hour to an hour at a time.

Follow-up sessions

Follow-up sessions also took place in school or college but I took with me activities designed to be similar to those on offer at the ISC but not quite the same (see description of

activities, Appendix I). Students worked in small groups for sessions of around half an hour.

Data gathering methods

Observation

The way in which my role fell somewhere between participant and non-participant, insider and outsider in the ISC has been discussed in the introduction. The fact that this made only incomplete observation possible was one of the reasons for the use of video-recording. Nevertheless careful field notes were made at the end of each session to supplement video material.

Still photography

Photographs can be used to provide a vivid illustration of what has been observed, however, selectivity is inevitable with this method and there is a risk that the very vividness of a particular image can bias reporting when it may not in fact have been typical. Still photography was used in the first of the preliminary studies and to some extent alongside video-recording in the second, but was not used in future stages.

Video recording

Video recording has a number of considerable advantages: videos capture body language, essential where the participants have little spoken language, in a way that still photography even combined with careful notes, cannot. Lewis (1994) has emphasised the importance of

recording non-verbal as well as verbal responses for students with learning difficulties and this was crucial in this study. In addition, videos can be re-viewed and re-coded any number of times and analysed later for checks on intra- and inter-rater agreement, although obviously only those sequences that were captured on camera at the time can be used. As with any method, some selection at the time was inevitable and it was important both at the data collection stage and at the data analysis stage to remain aware of this. There were a number of camera operators who were asked to focus on particular students in the second part of the main data collection cycles, as described above; they were briefed (and inevitably chose) to focus on interesting events in relation to these students. However, they were not aware of emerging hypotheses and would not therefore be tempted to select material to fit these. A greater number of cameras and camera operators would have reduced the need for choices and for selection that would risk giving a distorted picture, as it would have reduced the amount of 'off-camera' time for any given individual, but this would have had resource implications both human and material. A larger number of cameras would also have been more intrusive; with only one the students had only rarely seemed aware of it at all. In view of the above it was decided to use two video cameras for ISC sessions in Cycle 4, focusing on three pupils per group. Only one camera was used in school or college where there was less space; this was set up by me but with smaller groups and a smaller space it could simply be left running much of the time. A major drawback of using video-recording is that transcription of the videos is extremely time-consuming and this is only the beginning of the analysis process, nevertheless the advantages were felt to strongly outweigh the disadvantages. (For samples of video transcripts see Appendices III and IV. All video-recordings and full transcripts of all recorded sessions are available).

School/college records

Background information was elicited through a study of each student's school records: principally 'statements of special educational needs' and school reports.

Semi-structured interviews with teachers using videos to stimulate recall

The teachers from each group were shown video footage of sessions in school or college and ISC visits to stimulate recall and asked to comment particularly on how far they saw their students' behaviour as typical. Specific questions were not asked, rather a general request was made to the teachers to comment on the typicality or atypicality of the students responses and what they thought about them. These interviews provided a separate viewpoint ('slices of data' in grounded theory terms) for the purpose of triangulation and also gave interesting insights into the teachers' ideas about pedagogy, of their perceptions of the students' needs and how best to meet them and of their often conflicting aspirations for their students.

3.5.6 Data analysis

Data analysis again could be seen as a 'bricolage' of methods based on 'fitness for purpose'. Qualitative analysis was combined with small-scale quantitative analysis; Glaser and Strauss (1967, p.17) saw these two types of analysis as providing a useful complementarity in grounded theory research, stating that 'there is no fundamental clash between the purposes and capacities of qualitative and quantitative methods or data'.

Cycles of data analysis

The cycles of data analysis carried out within the research cycles are set out in Figures 5 and 6. During the first two cycles of the research (preliminary studies) analysis of video material was carried out at increasing levels of abstraction, starting with transcription of the videos. This was followed by a process equivalent to 'open coding' in grounded theory terms (Glaser and Strauss 1967, Strauss and Corbin 1998), which was used to code all video material from the second preliminary study.

During cycles three and four video material from the main data collection phases was again transcribed and 'theoretical coding' carried out for levels and types of engaged behaviour (see below and Appendix II for detail of how codes were derived and operational definitions). Material from the second preliminary study relating to students in the main study was also recoded in this way (see below). A first sequential analysis and the quantitative analysis were also carried out in cycle four. Re-interrogation of the data in relation to emerging hypotheses, in particular a second piece of sequential analysis were carried out in cycle five.

Methods of analysis

Description of sessions

For the initial, descriptive/exploratory, phase, the video recordings were used to provide detailed description of the students' responses to sessions in school, in the ISC and the follow-up sessions. This was combined with background information (school records) on

the students, and teachers' comments, to provide as rich and complete a picture as possible of each individual in each session. The other forms of analysis contributed to these descriptions.

Coding

No *a priori* coding system was used, although previous research in the ISC, literature relating to this and initial discussions with teachers formed a part of the background to the research (theoretical sensitivity in grounded theory terms) and had indicated areas of interest. A process equivalent to 'open coding' (Glaser and Strauss 1967, Strauss and Corbin 1998) was used in the second cycle of the research and designed to open up the theoretical possibilities in the data; all sections of the data from the second of the preliminary studies were coded in this way. Codes used were derived from previous research, initial literature review, initial observation and informal discussion with the teachers of the groups visiting the ISC for the preliminary studies; they were more abstract than the data itself and not merely descriptive (first level of abstraction). Coding was carried out directly from the videos rather than from the transcripts although recorded on these.

A process equivalent to 'theoretical coding' (Glaser 1978) followed, designed to interrelate substantive categories derived from 'open' coding. It had become clear from the initial stages of analysis and from ongoing discussion with the participants' teachers that an important feature of the students' responses was the degree of engaged and independent behaviour shown at the ISC. Codes relating both to level and type of engagement with the

activities were derived from the results of the ‘open’ coding combined with ongoing observation, discussions with the teachers and literature review (see Appendices II, III and IV for operational definitions of codes and samples of coded material). Codes were revised, amalgamated and simplified a number of times in discussion with supervisors, fellow researchers (‘critical friends’) and the person who subsequently carried out inter-observer agreement checks. All behaviour sequences that had been filmed for all nine students were then coded in this way, including re-coding of preliminary study visits. Coding was carried out directly from videos and recorded on the transcripts.

Colour-coded charts

Colours were allocated to each of the codes for level and type of engagement described above in order to build up a pictorial representation of each session for each of the main participants. Colour-coded behaviour sequences were set out along a time line to provide a continuous ‘state’ sequence and give an ‘at-a-glance’ picture of the sessions (see Appendix V).

Sequential analysis

A form of sequential analysis (e.g. Bakeman and Gottman 1997) was used to answer specific questions. By creating a continuous ‘state’ sequence along a timeline, as described above, it was possible to look not only at proportions of different behaviours but how they unfolded in time. By mapping ‘events’ on to the ‘state’ sequence it was possible to look at how these might be influencing behaviours; this was used to investigate specific questions, notably what led up to investigation or exploration by students and the effects of different

kinds of interaction with other people. It was not possible to carry out the kind of statistical calculation of the probabilities of a certain effect being the result of a particular event that preceded it described by Bakeman and Gottman (1997) and it was necessary to be cautious in drawing conclusions from this analysis, nevertheless it permitted a more thorough exploration of a number of questions and hypotheses than would have been possible from the data alone.

Quantitative analysis

Theoretical coding permitted the proportion of time spent in each type of behaviour to be calculated for each of the five main participants. This was carried out for each session and subsequently for separate components of ISC and follow-up sessions in order to compare language-based and active sections. Results were displayed in the form of colour-coded bar graphs for ease of eye-balling.

3.6 Reliability and Validity

3.6.1 Reliability

Reliability can be equated with consistency and replicability over time (Yin 1994; Cohen et al 2000 p.117), with demonstrating that the operations of a study could be repeated with the same results. Clearly it is not possible in this type of qualitative research for exactly the same study to be repeated but it is possible to conduct the research 'as if someone were always looking over your shoulder' (Yin 1994, p.37), making as many steps as operational

as possible and providing an audit trail: making available ‘raw data; processed data; procedures, designs, strategies; materials relating to intentions and dispositions (original proposal, personal notes etc); forms, schedules, observation schedules’ (Robson 1993, p.406). Samples of all stages of the present research design not incorporated in the main text are included in the appendices. Full field notes, videos and video transcripts represent far too great a volume of material to be included but all are available for inspection.

Reliability is also a question of ‘whether another observer with the same theoretical framework and observing the same phenomena would have interpreted them in the same way’ (Cohen *et al* 2000, p.119) and whether phenomena viewed from a different standpoint (the use of two or more methods of data collection) – provide the same interpretation (or confirming view) of the phenomenon. In the present instance this reliability was checked by a combination of inter-observer agreement checks, intra-observer agreement checks and triangulation.

Inter-observer agreement checks

Early in the project I trained a second, independent observer to code the video data. The coding system was trialled, modified and simplified in discussion with this person as well as ‘critical friends’ until we arrived at a satisfactorily functional system. I re-coded previously coded material and all new material using this system and the middle ten percent of all sessions in the ISC in Cycles 3 and 4 (main data collection) for all nine students were cross-checked by the independent observer. The number of seconds of

agreement (and disagreement) between researcher and second observer were noted and calculated as a percentage of the total number of seconds in each section:

$$\text{Percentage agreement} = \frac{\text{Agreements}}{\text{Disagreements} + \text{Agreements}} \times \frac{100}{1}$$

Kazdin (1982) suggested that agreement of at least 80% is needed to safeguard internal validity and agreement was well above this figure in most cases (see Figure 7). However, percentage calculations do not allow for chance and for this reason the statistical analysis designed by Cohen (1960), known as Cohen's '*kappa*' was also used: this is calculated by subtracting the proportion of agreements expected by chance (P_{exp}) from the actual proportion of agreements (P_{obs}), then dividing this by 1 minus the proportion expected by chance:

$$K = \frac{P_{obs} - P_{exp}}{1 - P_{exp}}$$

Bakeman and Gottman (1997) suggested that as 'a rule of thumb' *kappas* of less than .7 should be regarded with some suspicion. As can be seen from Figure 7, *kappas* calculated for inter-observer agreement in the present research were well above this.

Participant	No. agreements	No. dis-agreements	Total	% agreements	Kappa
Alan	285	20	305	93.4	.925
Alan	660	50	710	92.4	.914
Gemma	430	45	475	90.5	.893
Gemma	550	45	595	92.4	.914
Karen	655	45	700	93.6	.928
Karen	465	65	530	87.7	.861
Bill	575	110	685	83.9	.819
Bill	370	55	425	87	.853
Michael	435	25	460	94.5	.938
Michael	985	130	1115	88.3	.868
Louise	360	70	430	83.7	.816
Jackie	430	25	455	94.5	.938
Jackie	350	65	415	84.3	.823
Richard	205	15	220	93.1	.922
Richard	265	90	355	74.6	.714
Alex	270	65	335	80.6	.782

Figure 7: Inter-observer agreement

Intra-observer agreement checks

Intra-observer agreement was also checked. I re-coded extracts (again ten percent of all sessions in the ISC for the main participants) at least six months after the first coding; percentage of agreement and Cohen’s *Kappa* were calculated as above.

Participant	No. agreement	No. dis-agreements	Total	% agreements	Kappa
Alan	200	40	240	83.3	.812
Alan	485	25	510	95.0	.943
Gemma	170	10	180	94.4	.937
Gemma	380	50	430	88.3	.868
Richard	240	30	270	88.8	.874
Richard	375	15	390	96.1	.956
Karen	310	35	345	89.8	.885
Karen	330	35	365	90.4	.892
Bill	350	60	410	85.3	.834
Bill	345	15	360	95.8	.952
Jackie	330	0	330	100	1.0
Jackie	340	40	380	89.4	.880
Michael	315	15	330	95.4	.948
Michael	310	10	320	96.8	.964
Louise	510	20	530	96.2	.957
Alex	200	55	255	78.4	.757

Figure 8: Intra-observer agreement

Triangulation

Semi-structured interviews with teachers based on discussion of extracts from the videos were used to provide a separate viewpoint for the purposes of triangulation.

Triangulation is a vital element in the validation of any naturalistic research but particularly in this case where it was not possible to ask participants if they agreed with interpretations and where perhaps the greatest risk to validity was the possibility of misinterpretation of observed behaviour (see below).

3.6.2 Threats to validity

Internal validity concerns the question of whether or not the research shows what it purports to show (Cohen et al 2000 p.106). This section discusses potential threats to validity in the research design for the present study and steps that were taken to avoid these.

Miles and Huberman (1994) emphasised the need to check for the most common or most insidious forms of bias which they list as:

data overload leading to skewing of analysis; salience of first impressions or dramatic incidents; selectivity, over-confidence in some data especially when trying to confirm a key finding; co-occurrences taken as correlation or even causal relationship; extrapolation of number of total instances from those observed; unreliability of information from some sources; over-accommodation to information that questions a tentative hypothesis. (Miles and Huberman, 1994, p.438)

Safeguards put in place for the present research are set out below.

Selectivity

Some selectivity was built into the research design in the selection of participants, as described above, in the sense that the research was designed to explore what ‘may be or could be’ (Schofield 1993), nevertheless the aim was to avoid other types of bias as far as possible. The volume of data and the involvement of the researcher in both data collection and analysis made the type of selectivity described above a considerable risk in this project. This was safeguarded against in a number of ways: the fact that the researcher was not the camera-operator, so while filming will have reflected personal selections to some extent,

this was not related to emerging hypotheses. The videos of each session were then analysed in full and data continually re-checked and compared: 'constant comparison' in grounded theory terms (Strauss and Corbin 1998). Negative instances and alternative explanations were sought resulting in the re-formulation of hypotheses. Triangulation and inter/intra-observer agreement checks added to these safeguards.

Misinterpretation

Misinterpretation is clearly a risk in any interpretive research and particularly in this case where participants were not able to say whether or not they felt the researcher's interpretation to be a true one. Again triangulation and inter-observer agreement checks provided safeguards. The teachers, who knew the participants well, were asked to comment on their responses in video material from both ISC and school/college sessions (semi-structured interviews); this provided a cross-checking of the researcher's interpretation of responses as well as an indication of the typicality or otherwise of responses for individuals. Video material was also shown to a number of people who did not know the students at all; the person who carried out inter-observer agreement checks and, less formally, supervisors and fellow researchers who became 'critical friends'. Comments from all of these people confirmed my view that for all of these students, expressions and gestures of pleasure, triumph, frustration and so on could be read just as they would for people without learning difficulties.

Causality

Yin (1994) emphasised the need to be constantly aware of possible alternative explanations in seeking causal links; an example in the present instance might be the effect of a visit out of school regardless of its content. A part of the purpose of the follow-up visits was to observe the students using similar activities in a situation that did not involve a trip. Care was taken, particularly in the explanatory phase, to avoid assuming that because one event followed another it was caused by it; this has been discussed above in relation to the use of sequential analysis.

Reactivity

There is a risk in all naturalistic research that the presence of the researcher and the means of recording observations will affect what is observed. In this case, as the researcher, I had a role in the sessions, so was a part of what was being observed, having an influence on it but little more than I would have had in any session. The presence of video cameras would have been more likely to have an impact and it was necessary to accept a compromise between the number of cameras that would have given a complete record of every session for every student, and having a small enough number to avoid them being too intrusive.

3.7 Generalisability

A criticism frequently levelled at interpretive research and, in particular, at case study methodology, is that it is not generalisable beyond the particular case or cases. Stenhouse (1988) argued that generalisation is not an essential outcome of case study research and

Schofield (1993, p.92) stated that 'many qualitative researchers actively reject generalisability as a goal'. However, other authors (Yin 1994, Lincoln and Guba 1985, Tripp 1985, Stake 1995) have maintained that generalisation from qualitative research is possible but in ways other than that generally envisaged in positivist research; these are discussed here in terms of their applicability to the present research.

A case may be interesting in itself, case study is widely used for example in medicine; 'the study of individual cases has always been the major (albeit often unrecognised) strategy in the advancement of knowledge about human beings.' (Valsiner 1986). Stake (1995) described as '*intrinsic case study*' the study of something that may be so important, interesting, misunderstood or unique in important respects that it deserves study in its own right. Schofield (1993) suggested that it may be possible to generalise 'to what may be' or 'to what could be'. (p 98), selecting a situation that is in some way exceptional so that it sheds light on what could be, given the right circumstances (Schofield 1993, p105). The aim of the present research was to explore a situation that had not previously been studied and that could therefore shed light on what 'could be' in these circumstances.

Lincoln and Guba (1985) suggested that naturalistic enquiry encourages generalisation because 'it makes contact with the readers' own tacit knowledge of related or similar situations.' Tripp (1985) called this 'qualitative generalisation', Stake (1995) 'naturalistic generalisation'. They also suggested replacing the concept of generalisability with one of 'fittingness', analysing the degree to which the situation studied matches other situations in which one is interested and for this, Schofield (1993) noted, detailed description is vital. It is hoped that the present research will make contact with readers' experience and one of the

aims was the kind of rich description that makes this possible; implications for practice are discussed in Chapter 5.

Yin (1994) went a step beyond this; he suggested that when case study methodology is criticised for lack of generalisability, this is based on a mistaken analogy with survey research, which allows statistical generalization from a representative sample to a wider population. Case studies (like experiments), he maintained, rely on 'analytical generalization', that is generalisation to theory. In other words they can be compared against an existing theory or theories in terms of whether or not they provide further support for a particular theory and/or do not support a rival theory. In the present study propositions and hypotheses were examined in relation to the literature.

Stake (1995) distinguished between 'petites généralisations' and 'grandes généralisations' in relation to case study; the former being general statements made within a study, for example that a certain participant repeatedly responds in a certain way to a particular situation. This was important in the present study where one of the most striking aspects of the findings was the extent to which students' responses were different in different situations but in a way that was consistent within these situations. Stake (1995) urged interpretive researchers to be wary of 'grandes généralisations', general statements about issues of which the case may be an example, arguing that 'propositional generalizations', assertions based on the data, were more appropriate to interpretive research. Nevertheless, here too he urged caution, the need to make clear the speculative nature of such assertions and to be open to other interpretations: 'Good case study is patient, reflective, willing to see

another view of the case. An ethic of caution is not contradictory to an ethic of interpretation'. (Stake 1995, p 12)

Punch (2005) also argued that interpretive research and in particular research using grounded theory strategy may be used to generate propositions and to extend or develop theory, in this case the findings can be seen as *potentially* applicable to other cases (Punch 2005). Hypotheses generated by and grounded in the data are explored and implications for future research discussed in Chapter 5 following the presentation of the findings.

CHAPTER 4: FINDINGS

This chapter presents the findings from the research starting with the preliminary studies. This is followed by descriptions of all sessions (in school or college, in the ISC and follow-up sessions) for all of the participants. In the third section of this chapter findings from the semi-structured interviews with the participants' teachers are presented followed by presentation of findings from the two pieces of sequential analysis that were carried out on the data from the ISC visits for the five main participants. The last section constitutes a summary of the findings beginning with the bar graphs showing the proportion of time spent in different types and levels of engagement in the separate sections of each session for each of the five main participants which provide a visual summary. This is followed by consideration of the findings in relation to each of the questions posed in the descriptive/exploratory phase of the research.

4.1 Preliminary Studies (Cycles 1 and 2 of research design)

4.1.1 Preliminary study 1

The first of the preliminary studies was designed to begin to explore the very broad question of how students with severe learning difficulties might respond to the type of activities and relatively unstructured learning environment of the small ISC described above.

A group of eight students from a special school visited the science centre with their teacher and three other members of staff. There was a wide age-range from eight to sixteen; the two eight year olds were not normally in this group but had been substituted for two students who were ill.

The activities at that time related to Forces and Movement and included a wind tunnel with toy cars to test in it and card to change the shape of the chassis, a large solenoid (electromagnet) and objects made from a variety of materials to test with it (see Appendix I for full descriptions and photographs). The group was given a very brief demonstration of some of the possibilities of the various pieces of equipment and then encouraged to choose their own activities without adult direction.

Data gathered through still photography was used to reinforce careful notes taken during the session. Four categories of response of particular interest were noted: multi-sensory involvement, concentration, curiosity, collaboration. Staff accompanying the group remarked on an unusually high incidence of the last three.

Multi-sensory involvement



Enjoyment of sensations produced by wind from the Wind Tunnel or from hitting a rubber sheet stretched across a barrel, or by feeling the pull of an electromagnet was evident.

Concentration

The group was excited and slow to settle at first but most of the pupils became very involved in what they were doing. Paul, a young man of sixteen with Down syndrome, spent a long time re-shaping cars to try in the wind tunnel. He added card or paper to the cars, tried them in the wind tunnel and then adjusted what he had done. His aims in doing this and his understanding of the concepts involved were difficult to gauge due to his communication difficulties but what was abundantly clear was his involvement with this and with other activities. The involvement of other students was equally apparent.



Curiosity

Understanding may have been difficult to gauge but curiosity, the desire to find out what was going on and interest in cause and effect was apparent. Again Paul showed this most obviously. The photo shows him attempting to find out what has happened to the iron bar that has been drawn into the solenoid:



Collaboration

Some of the activities appeared to encourage collaboration. The two youngest children spent a long time working at the solenoid, each carefully putting one of the objects provided in at her end and waiting to see if it would ‘click’ with her partner’s in the middle (a sharp pull can be felt if two magnetic substances are brought close to each other inside the solenoid and two iron bars are almost impossible to separate, once joined, when the magnet is switched on). Their faces showed anticipation of this pull. Their teacher remarked that it was unusual for them to work together at school.



Issues raised by the initial study

This initial preliminary study had indicated a number of positive aspects that appeared to be linked to the ISC as a learning environment for these students but it also raised a number of important practical issues and these shaped the design of the remainder of the research:

- The need to record more accurately: still photos provide, by definition, only a snapshot, and make it all too easy to draw false conclusions. It was decided that the use of a video camera would provide a much more accurate record of visits and one that, importantly, would record body-language as well as spoken language.
- The need to find some way of checking what had been gained from a visit, of evaluating recall, understanding and the ability to use what had been learnt in a slightly different context (transfer). The very limited language of most of the participants ruled out using interview to do this and it was decided to incorporate follow-up sessions into the second of the preliminary studies as well as using video recording.

4.1.2 Preliminary study 2: video-recorded sessions

The second of the preliminary studies was aimed at piloting the use of video recording as a tool in this setting with students with SLD. It was also designed to look more closely at the behaviours outlined above that had been remarked on by the teachers, as well as other possible responses.

Video-recorded session 1

The first group to be videoed were young people with SLD from a College of Further Education. The study focused on Darren, aged eighteen, and Gemma, aged seventeen. Only one video camera was used and it was found to be impossible to follow both participants throughout.

Activities at this time related to Energy and Electricity and included a 'water-lift' with a water-wheel, a variety of electric circuits, a 'breathing' skeleton, a house with temperature probes linked to a computer and a wind generator (see Appendix 1 for full description and illustrations).

The session is described below for Darren; Gemma was a participant in the main phase of the research as well as the preliminary phase, and findings from the preliminary study session are presented for her with those of the main study. In the description below 'teachers' and 'learning support assistants' refer to members of staff from the college, 'helpers' are science centre staff, including myself. Figures in brackets indicate the time from the start of the session in minutes and seconds.

Darren

At the start of the session, during the demonstration, Darren is standing making 'windmill' motions with his arms, he is not looking at the equipment that is being demonstrated or at other things in the room, his attention does not appear to be focused on what is happening around him. Nearly eleven minutes into the session (10.55), he is encouraged by his teacher to go to the Water-Lift. At first his attention appears only intermittently engaged and he reverts frequently to turning the handle with his thumb in his mouth and no apparent interest in the effect he is producing. Verbal input from his teacher (15:05) has no obvious effect and he continues to turn without looking at what is happening, although he calls on a classroom assistant to look shortly afterwards (16:45) and later more or less echoes the teacher's words when he points to water coming out of the pipe and says, '*Do you see, water coming out of pipe, at bottom, look*'.

As the session progresses Darren becomes increasingly involved in what is happening, recognising when there is not enough water, at first asking a helper for more to solve the problem (26.18) later filling the reservoir himself (27.15, 50.50). When this produces the desired result he communicates this to the helper (51:20: '*works now*'). The use of light, non-verbal scaffolding (48.65) by a helper, showing him how the tube can be adjusted to increase the flow of water onto the water wheel, appears to increase Darren's involvement as he first imitates and then begins to experiment, making his own adjustments (49.40), showing real interest in the effect he is producing (52.30) and goes on to speed up the turning of the handle and to observe the effect this produces (55.40). He is able, when asked (56.30), to show the entire path of the water and the effect it produces.

Darren spent most of the hour long visit at this one activity, apart from brief times at others. The initial choice of activity was prompted by his teacher but returning there was entirely his choice, indeed his teacher made one or two attempts to move him away from the Water-Lift to try something else. He progressed from automatic turning of the handle to closely engaged attention to basic problem-solving and experimentation. The video camera captured most of this progression in a way that still photography combined with simple observation, however painstaking, could not

have done. It also captured the fact that it was not a straightforward progression: Darren reverted to apparently automatic turning of the handle a number of times.

It was clear from this sequence that a distinction needed to be made between different types of concentration, between focused (or engaged) and unfocused attention. Darren spent a great deal of time at the beginning of the session carrying out a single activity with what could be described as great concentration but concentration that appeared unproductive in terms of learning. Darren's activities also demonstrated the time needed for progression from repetitive behaviour to interest in cause and effect and from this to investigation for some of these students; stages in the model of progression from play to investigation proposed by Brooke and Solomon (1998) that are often passed through very rapidly by mainstream pupils.

Video-recorded session 2

The second group to be video-recorded were from a special school class on a mainstream secondary school site. The study focused on Karen, aged twelve, Jackie, aged fifteen and Bill aged sixteen. They were filmed (again with a single camera) at the ISC and also carrying out follow-up activities in school two weeks later. The activities in the science centre were the same as for the previous group. All three students were also participants in the main study so detailed findings are reported there.

These videoed sessions confirmed high levels of concentration and curiosity at the ISC and accompanying staff also remarked on these. Co-operation or collaboration between pupils was less apparent, however, indeed at times it was the reverse that was striking, although there did seem to be a desire to communicate achievement.

Informal discussions with teachers

These discussions had an important bearing on the decision to carry out semi-structured interviews with the teachers of the pupils in the main study. Initial discussions were carried out on an informal basis with teachers accompanying groups. These suggested that they were witnessing unusually high levels of motivation and engagement, curiosity and exploration, behaviours which they implied were normally problematic for their students. High levels of collaboration observed in the first group were only rarely repeated during the preliminary studies.

Analysis of video material

Open coding was carried out on video material from the preliminary study and findings informed subsequent questions and theoretical coding.

4.2 Pen-portraits and Description of ISC, Follow-up and School/College Sessions for All Participants

Accounts of each session attended are reported in full for the five main participants (Alan, Gemma, Karen, Bill and Michael), more concisely for the other four (Richard, Jackie, Louise and Alex). Descriptions and photographs of ISC and follow-up activities are presented in Appendix I. Sessions are presented for the first participant, Alan, with the colour-coded timelines interspersed to show how these were built up. These timelines provided visual summaries for all sessions for the main participants and are presented in Appendix V.

Not all of the students took part in the preliminary study and some were absent for occasional sessions in the main phase of the research. The following table shows the different sessions for each student and their place in the research design:

	Preliminary Studies (Cycle 2)	Main Data Collection Phase Year 1 (Cycle 3)	Main Data Collection Phase Year 2 (Cycle 4)
Major participants			
College group			
Alan		College 1, ISC 1, Follow-up 1	College 2, ISC 2, Follow-up 2
Gemma	ISC 1, Follow-up 1	College 1, ISC2, Follow-up 2	College 2, ISC 3, Follow-up 3
Secondary school group			
Karen	ISC 1, Follow-up 1	School 1, ISC 2, Follow-up 2	School 2, ISC 3, Follow-up 3
Bill	ISC 1	School 1, ISC 2, Follow-up 1	
Primary school group			
Michael		School 1, ISC1, Follow-up 1	School 2, ISC 2, Follow-up 2
Minor participants			
College group			
Richard		College 1, ISC 1, Follow-up 1	College 2, ISC 2, Follow-up 2
Secondary school group			
Jackie	ISC 1, Follow-up 1	School 1, ISC 2, Follow-up 2	
Primary school group			
Louise		School 1, ISC 1, Follow-up 1	
Alex		School 1, ISC 1, Follow-up 1	

Figure 9: Table showing when sessions for each student took place during the research

4.2.1 Alan

Pen-portrait

Alan was sixteen when he first visited the ISC and a student on a course designed to prepare students for independent living at a college of further education.

College records noted that Alan had Down syndrome, had poor eyesight and poor hearing in the left ear. They also noted that the curriculum for Alan consisted of the 'three Rs' and skills for independent living. He was said to have developed some self-help skills but his work rate was reported as having regressed.

Subject reports stated that in English Alan rarely wrote independently and progress in reading was very slow with understanding questionable. It was suggested that he might have reached a plateau. In maths he was said to be able to count to twenty and carry out simple subtractions with help and in science that he always worked with adult support but at times appeared to be interested in the work and had 'even volunteered an answer on occasion'. Targets specified in Alan's college records included: improving his speech delivery so he could be more easily understood; extending his vocabulary; *getting* him to do things by himself (my italics); working on fine motor skills; keeping on task.

Alan's teacher described him as 'quite able' but not fulfilling his potential, waiting to be told what to do,: *'He just stands there waiting, he won't do anything until somebody tells him what to do...He knows exactly what he has to do but he chooses not to. Life is much easier if you get told what to do ... you know you can say, 'What are you supposed to do?', you can rephrase it ...He has days when he actually gets on with it'*. She said that Alan's concentration span was limited, that he soon '*switches off*' but later added, somewhat contradicting what she had

previously said, *‘he’s quite deep, he just doesn’t appear to be listening, like look at his expression now he seems to be drifting but he’s listening ...if you can get him to reply you can see that he was taking it in’*. The teacher felt that all the students behaved differently at the science centre but saw Alan as being the most different in that environment and this was borne out by the videos. She commented as she watched the video of Alan at the ISC: *‘here he went on and on, trying it out, moving things, adjusting them, total concentration. That’s amazing concentration for him and he’s obviously thinking. Look at his smile, look at his contented smile of anticipation ... nobody interfered, he was allowed to get on and he’s working quite fast considering ... That’s nice to see him work totally on his own’*.

Alan - Description of sessions

Alan did not take part in the preliminary studies so all sessions described below for him took place in the two years of the main phase of data collection (Cycles 3 and 4 of the research): College 1, ISC 1 and Follow-up 1 took place in Cycle 3, College 2, ISC 2 and Follow-up 2 took place the following academic year in Cycle 4.

Key:

a	b	c	d	e	f	g
Not focused on activity	Initial interest	Playing/trying out	Following instructions	Working to goal	Making adjustments	Investigation/exploration

x	o
Uncodable	Off camera

If elements of two categories were observed both codes are given, e.g. a/b, d/e, but colour-coding is to the lower.

Times given are in minutes and seconds from the start of each session, rounded to the nearest five seconds.

College session 1

Alan was filmed in college for the first time during the first year of the main data collection phase (Cycle 3), his group was making Christmas cards for sale at a later date. They were filmed for just over one hour; for the first thirty-five minutes the group of seven were sitting round a large table with three LSAs while the teacher went over what had been done in the previous card-making session and what was to be done in this one. She made notes (written and pictorial) on a whiteboard and the previous session's work was there for students to look at. During the second half of the hour the students worked at tasks allocated by the teacher, mainly in pairs with a member of staff, each pair being allocated a different stage of the card-making process.

a/b										o					a/b									
0;0	10	20	30	40	50	1;0	10	20	30	40	50	2;0	10	20	30	40	50	3;0	10	20	30	40	50	4;0

The teacher tells Alan to look at her while she is talking so she knows he is listening then tells him he has got to listen really carefully as he missed last week's session: '*so no slacking for you today*'. Alan looks at her when he is directly addressed then down at the table, fiddling with his pencil. The teacher asks the others to show Alan the cards they have made, he looks and smiles when another student holds his folder out (0.45). The teacher then asks the others to describe what they did last week for Alan (1.0) which they do with frequent prompts from her. Alan sits with his arms folded looking down at his hands or at the table, at one point (2.05) he rests his head on his arms, until the LSA sitting next to him taps him on the shoulder when he sits up and adjusts his glasses. After a little over a minute off-camera (2.25-3.35) he is still in the same position and when the LSA whispers something to him he doesn't reply but puts his head on his arms. He lifts it again when the teacher says 'Alan' although she is in fact talking to another student of the same name.

o										a/b														
4;0	10	20	30	40	50	5;0	10	20	30	40	50	6;0	10	20	30	40	50	7;0	10	20	30	40	50	8;0

He is off-camera again for two and a half minutes (4.0-6.30) and when he is seen again he has his head down once more. The teacher says she wants to show another student's work to

Alan, the LSA taps him on the shoulder and he looks up but quickly down again. The LSA whispers something, Alan looks at him but when the LSA points at the teacher looks quickly down again. The teacher moves on to getting the students to list what they will need to make more cards that day. Alan looks occasionally at the speaker, or at the LSA if he whispers to him or points something out, but doesn't respond.

a/b															o									
8;0	10	20	30	40	50	9;0	10	20	30	40	50	10;0	10	20	30	40	50	11;0	10	20	30	40	50	12;0

Alan remains sitting with his head down most of the time, occasionally looking up when another student speaks.

o															a/b									
12;0	10	20	30	40	50	13;0	10	20	30	40	50	14;0	10	20	30	40	50	15;0	10	20	30	40	50	16;0

He is off-camera for over three minutes (10.50 – 14.20) after which he is still looking down, rubbing his eyes and adjusting his glasses apart from a very brief wave to the camera (15.10). When the LSA next to him whispers to him he looks up briefly then down again. He puts his thumb in his mouth but removes it again when another LSA shakes her head at him.

a/b										b		a/b												
16;0	10	20	30	40	50	17;0	10	20	30	40	50	18;0	10	20	30	40	50	19;0	10	20	30	40	50	20;0

At one point the teacher is asking another student named Alan to name a star shape; when he is unable to do this she says '*Perhaps the other Alan can help us?*' Alan looks up briefly when his name is mentioned then away again. The LSA says '*That's you, N (teacher's name) is talking to you.*' Alan looks up but then quickly away again (17.30). The LSA says '*What shape, Alan? What shape is this?*' pointing at Alan's folder and making the sign for 'what?' which Alan repeats. Alan says something inaudible and the LSA says '*He said it's a star.*' The teacher turns her attention to another student and Alan adjusts his sleeve (17.50), continuing to look down most of the time but becoming slightly more restless, tapping his hand on his arm, lying back in his chair as the teacher continues to elicit from the others how they made the cards last time, step by step.

a/b					o										a/b									
20;0	10	20	30	40	50	21;0	10	20	30	40	50	22;0	10	20	30	40	50	23;0	10	20	30	40	50	24;0

At 21.55 the teacher asks the class to estimate how many cards they will be able to make that morning. Again Alan looks up occasionally when another student speaks, but when the teacher says '*Alan, have you any thoughts?*' he looks round then right down as if to avoid the question. The teacher's attention is distracted by another student.

a/b					b					a/b														
24;0	10	20	30	40	50	25;0	10	20	30	40	50	26;0	10	20	30	40	50	27;0	10	20	30	40	50	28;0

The teacher turns her attention back to Alan and the following exchange takes place: Teacher: *‘Alan, what about you? How many cards do you think we might make?’* LSA: *‘How many cards? How many of these do you think we could make today? In three or four hours?’* Alan: *‘Both’*. LSA: *‘Both?’* Second LSA: *‘How many do you think, Alan?’* First LSA: *‘Gemma thought fifty, Richard twenty, W(LSA) thirty, K (LSA) sixty and I thought ten. How many do you think?’* Second LSA: *‘Is there a prize?’* (laughter). Alan: *‘Thirty-four’*. Teacher: *‘Thirty-four? Very precise’*. As soon as this exchange is finished (26.0), Alan returns to looking down, away from the teacher and when she repeats a question looks even further down.

a/b	o										a/b	o												
28;0	10	20	30	40	50	29;0	10	20	30	40	50	30;0	10	20	30	40	50	31;0	10	20	30	40	50	32;0

Alan is only briefly on camera for the next four minutes (28.10 -32.10) and there is no change in his demeanour when he is.

o	a/b					o	d	o	a/b	d	a	d	a/b											
32;0	10	20	30	40	50	33;0	10	20	30	40	50	34;0	10	20	30	40	50	35;0	10	20	30	40	50	36;0

The teacher tells the students they are going to make the cards as a ‘production line’. At 35.40 the LSA who has the sheet of instructions for Alan’s part in the ‘production line’ tells him to get up and follow her. Alan is briefly off camera and when he is on again he is standing near to Gemma’s table, looking around, then moves closer to it and stands looking down at it, tapping his fingers on his face. An LSA takes him by the arm and turns him away but is then distracted and takes her hand away. Alan stands still where she has left him for several seconds, peers around a pillar (at the camera?), then wanders over to another table and stands still beside this one. The LSA brings equipment and puts it on the table by Alan who leans over it but when the LSA turns her attention to the other Alan (35.50) turns round and stands still again.

a/b	x	o					b	o	a/b					o										
36;0	10	20	30	40	50	37;0	10	20	30	40	50	38;0	10	20	30	40	50	39;0	10	20	30	40	50	40;0

Alan moves to where another student has joined Gemma (37.10) and stands watching briefly until the LSA moves the other student again. Alan continues to stand for a while then follows them, smiling at the camera as he passes, and stands behind the other Alan rubbing his face for over a minute.

o					a/b					b					o																			
40;0	10	20	30	40	50	41;0	10	20	30	40	50	42;0	10	20	30	40	50	43;0	10	20	30	40	50	44;0										

He is off camera for over a minute (39.20 – 40.45) then seen leaning briefly over a paper in front of him, scratching his head and adjusting his glasses. He shows more interest as the LSA starts to prepare the materials and show him what to do (41.05).

o															d					a		a/b				
44;0	10	20	30	40	50	45;0	10	20	30	40	50	46;0	10	20	30	40	50	47;0	10	20	30	40	50	48;0		

After nearly five minutes off camera Alan is seen slowly drawing round a square while the LSA holds the template (46.30 – 47.0). At 47.0 the LSA takes the template off and moves away to get something. Alan sits still again then looks down at the table.

a/b		d	o																									
48;0	10	20	30	40	50	49;0	10	20	30	40	50	50;0	10	20	30	40	50	51;0	10	20	30	40	50	52;0				

At 48.15 the LSA holds the template again for Alan to draw round.

o	b				d	a	a/b	o	b	a	d					b	d	b	o					
52;0	10	20	30	40	50	53;0	10	20	30	40	50	54;0	10	20	30	40	50	55;0	10	20	30	40	50	56;0

After nearly four minutes off-camera (48.25 – 52.10) Alan is sitting by the LSA watching while she draws a line with a ruler, saying, ‘*Like this, look*’. She places the ruler on the paper then gives the pencil to Alan (52.45) and takes his hand. Alan looks up rather than at what he is doing as the LSA moves his hand to draw the line but does then look down. The LSA places the ruler for a new line and takes the pencil (53.10). Alan looks up, smiles and waves, the LSA, distracted by someone else, draws the line herself. She places the template against the line then holds out the pencil and nudges Alan to take it. He is off camera briefly (53.45- 53.55) then seen holding the pencil and watching. The LSA is looking for something and is then distracted by another student (54.0) Alan doesn’t move for a few seconds then puts the pencil down on the paper. When the LSA returns her attention to him Alan looks closely at the ruler (he is very short-sighted), grimaces and draws a line. The LSA points to another line to be drawn, Alan draws it, then another. The LSA moves the template and Alan draws again, she tells him to press harder because the others (those who are cutting out) can’t see the lines. She takes Alan’s pencil and goes over all his lines again. She tells Alan to take the ruled board over to Sam (fellow student) adding ‘*Don’t be long*’. He takes the board to Sam and Richard (55.35) and stands looking over their shoulders. From 55.50 he is off camera for the rest of the session (nearly 10 more minutes).

Comments

During the first half of the session, Alan barely responded to the talk going on around him, looking at the speaker when he was directly addressed but mostly down at the table (he had missed the previous session so is unable to participate in discussion of this). He occasionally smiled briefly, usually at a fellow student or at the camera, but generally his face appeared expressionless and it was difficult to know how much he was taking in of what was being said. He did not reply to questions unless they were directly addressed to him and even then they often needed to be repeated before he answered. When the teacher addressed a question to the group as a whole Alan often looked away, suggesting perhaps that he wanted to avoid being chosen to answer. During this first part of the session Alan never participated of his own accord and his level of engagement was mainly coded as 'a/b' (inactive, no obvious response), with some 'b' (interested) or 'd' (following instructions).

During the practical part of the session Alan complied with directions but stood or sat still, looking down or around the room, or adjusting his clothes or glasses, as soon as direction stopped. The practical task Alan was given was to draw round a square template held by the LSA who guided his hand. Alan did draw several lines on his own but the LSA went over them again saying the others couldn't see them. She then told him to take the board to the next group. No other activity was recorded and, again, at no point did Alan's level of engagement appear to exceed category 'd' (following instructions). The end-product (the Christmas cards) was to be sold, which could be part of the reason for the amount of direction the students received.

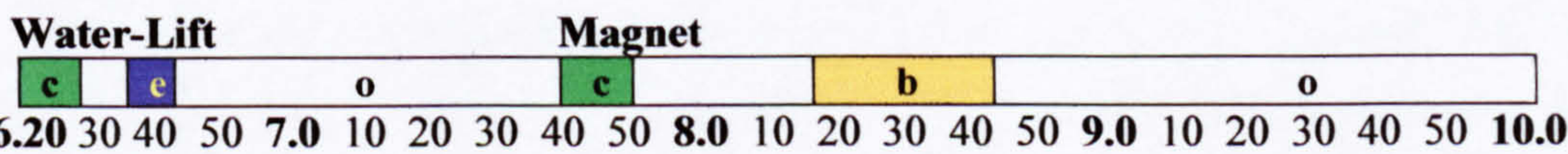
ISC 1

Alan’s first visit to the science centre also took place during the first main data collection cycle (Cycle 3), he had never been before. Activities related to Forces and Movement.

Demonstration

During the first six minutes of the visit the group of four students and three members of college staff are taken round the activities and introduced to them verbally and by demonstration. Alan shows little interest, following the group when prompted, looking at the floor or the equipment but taking no active part in what is happening until a helper (H1)¹ asks who would like to hit the ‘Thump Wave’ drum. It is unclear whether Alan volunteers or whether his teacher suggests he should do it. He is brought to it by the teacher and told to tap the rubber sheet by H1, which he does very tentatively. This has no effect and the instruction is remedied to ‘hit’. He then needs to be encouraged to look at the clown to see the effect he is producing. Alan continues to hit the drum after the group have begun to move on but shows no particular interest in what he is doing. When H1 asks if any of the group go swimming and whether they know what it feels like to push against the water Alan says, ‘Yes’, but does not respond otherwise during the introduction. The group are invited to go to the activity of their choice, Alan moves off - camera with H1 who is asking him what he would like to do.

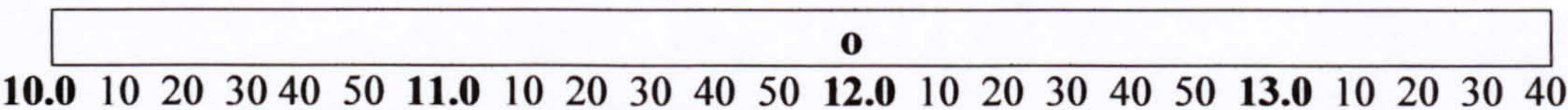
Activities



When Alan is next on camera (6.20) he is standing by the Water-Lift turning the handle, a helper is beside him, having probably shown him what to do. As the helper moves away, Alan’s level of engagement immediately appears to rise as he looks closely at the Water-Lift cups. He is briefly off-camera and when he is on again is kneeling beside the equipment. An LSA tells him his trousers are getting wet (the floor is frequently damp by the Water-lift), Alan changes to a squatting position but continues to turn the handle looking closely at what

¹ Teachers and learning support assistants (LSAs) are college or school staff, helpers are ISC staff including myself (H1).

he is doing. After about two minutes he begins to turn the handle one way and then the other looking at the cups, apparently interested in the effect he is producing. After approximately two and a half minutes someone suggests that another student should look at the electromagnet. Alan gets up and follows, perhaps thinking the suggestion was meant for him.

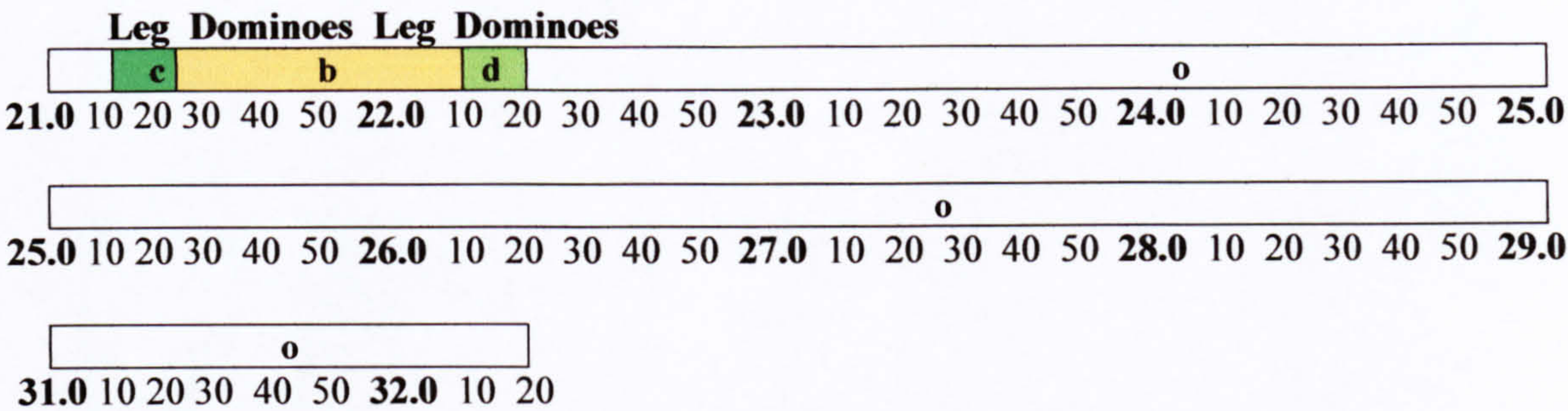


Alan is off-camera for about five minutes and when he is next seen (13.55) he is standing by the pulleys with an LSA who appears to have been untangling the ropes for him. The LSA stands back and Alan appears to have a clear goal in mind and a clear idea of how he wishes to achieve it as he carefully separates the two ropes, looks up at the pulley, selects one of the ropes and pulls on it. He adjusts his feet and glasses and continues to pull on the rope watching intently. He has some difficulty with the equipment and accepts staff intervention to help with this (14.35 -14.55) but otherwise appears entirely focused.

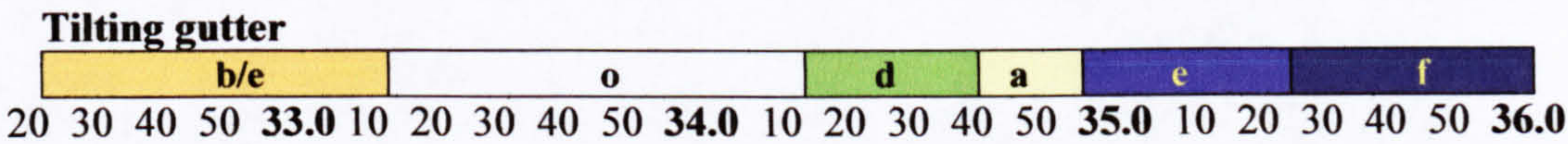


Alan is off-camera for over half a minute (16.10-17.00) and is then being encouraged by an LSA to move to another piece of equipment (17.00 - 17.10). When he is next on camera, after a few seconds, he is standing by the Wind Tunnel and the LSA is standing back against the wall. Alan clearly knows what to do: he switches on the wind, picks up a car with card on the back and places it at the top of the sloping ramp. He lets go with a dramatic gesture, the car does not move. This does not seem to be what he expected, he stands looking at it, his gesture frozen, for several seconds (in the introductory demonstration cars probably went down the ramp. It is also likely to be counter to his previous experience of placing an object with wheels at the top of a slope). The LSA, who can see Alan but not the car, asks what is happening, Alan replies, *‘Nothing’*, (perhaps meaning the car is not moving). She tells him to try other cars, which he does, remaining interested, working to direction, until a helper distracts the LSA. Alan, left alone, seems very clear about what he wants to do. He begins to change the cars, fitting a roof to one that has had it removed. When he places this on the ramp he again stands back dramatically and this time the car rolls down. He repeats this, this time without the dramatic gesture, looking into the tunnel; he appears puzzled and had perhaps expected it to remain stationary as the car with card on the back had done. He goes on to try other cars, releasing them in slightly different ways and peering into the tunnel. He appears curious about the effects being produced and to be exploring these to find out more. When he

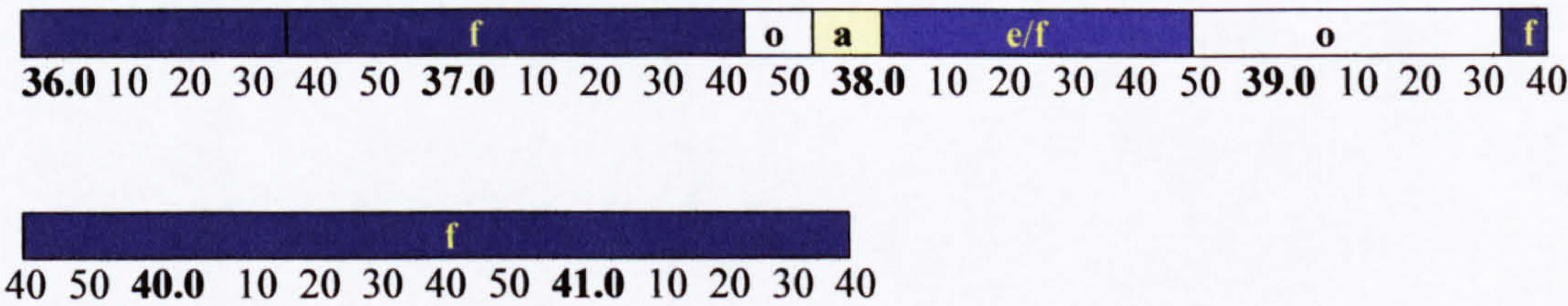
has tried all the cars again he switches the wind off, apparently satisfied (20.00). The helper asks which was the best, Alan replies, 'Yeah', perhaps not having understood or not wanting to make the effort to reply. When the question is repeated he points vaguely in the direction of the cars but still doesn't really answer. As soon as he is addressed verbally he appears less engaged.



Alan is off-camera for one minute (20.10-21.10). He is next seen at the Disembodied Leg, pulling at the string muscle, but quickly wanders over to watch Gemma and Richard (fellow-students) at the Dominoes (21.20). The teacher asks Alan if he can make the leg kick (21.25) and he wanders back towards it, looks in the box beside it but then returns to sit by Gemma at the dominoes when she beckons (22.10).



Alan is off-camera for nearly ten minutes then joins fellow-students Sam and Richard at the Tilting Gutter (32.25), sitting down beside the bucket into which they are aiming the ball. Alan's eyes appear to follow the ball but not all the way down; his reactions often seem very slow. He watches for a few minutes, from time to time adjusting the bucket to Sam's directions. Sam frequently directs Alan in the same way as the teacher does. On one occasion Sam readjusts Alan's adjustment and Alan stands briefly immobile (34.40-34.55). Then Sam hands him a ball, which Alan tosses in the air and catches. Sam moves away and Alan begins to work to his own agenda (35.00).



As soon as Alan is left alone he appears to be working to a definite goal, carefully positioning the ball on the end of the gutter and tilting it as the ball rolls, which the others were not doing. He continues to try various positions of bucket and gutter with great care and concentration,

sometimes appearing to test and measure the tilt of gutter before putting the ball on. He continues for nearly five minutes despite the fact that the ball misses the bucket every time. He does not seem able to note where the ball falls and place the bucket there, although he clearly is aware of the need for adjustment (the speed of the ball and poor eyesight may make it difficult for him to note where it lands). When the ball finally bounces into the bucket (39.40) watching staff applaud and Alan's broad smile implies a sense of achievement. This may be a response to their response but he seems to have clearly held the goal of getting the ball into the bucket and to have tried different combinations in pursuit of this, although he does not seem to be exploring out of curiosity as he did at the Wind Tunnel. He continues for a further two minutes at which point (41.40) the video ends.

Comments

Alan appeared reasonably interested throughout, if others directed him he followed their directions passively, but there was a strong contrast in his demeanour when he was left to use the activities on his own initiative. The contrast with the session recorded in college, where he stopped doing anything when direction stopped, is striking. At the ISC Alan seemed to have a very clear idea of what he wanted to do when he was on his own, and to set himself goals, especially at the Wind Tunnel and the Tilting Gutter. At the Wind Tunnel, his surprise at a car that does not behave as he expected, that remained stationary instead of rolling down the slope, appeared to lead to investigation.

Follow-up 1

The first follow-up session for Alan took place in college two weeks after his first visit to the ISC during the first year of the main data collection phase (Cycle 3).

Activities similar to, but not the same as, those at the ISC were taken to the students' school or college two to six weeks after their visit for follow-up sessions. The first follow-up session in college for Alan took place just over three weeks after the first visit to the ISC.

Discussion

a/b					b					a/b					b					a/b				
0;0	10	20	30	40	50	1;0	10	20	30	40	50	2;0	10	20	30	40	50	3;0	10	20	30	40	50	4;0

At the start of the session H1 speaks to the whole group asking them if they remember their visit to the science centre and what they did there. Alan does not participate at first, tending to look down at the table when questions are addressed to the group as a whole.

a/b										b										a/b									
4;0	10	20	30	40	50	5;0	10	20	30	40	50	6;0	10	20	30	40	50	7;0	10	20	30	40	50	8;0					

Even questions addressed directly to him are answered in monosyllables until he is asked if he had a go with the cars (5.50). He replies ‘Yes’ and when asked what happened says, ‘*nothing happened*’ (these are the words he used at the ISC, perhaps meaning the car didn’t move). When H1 asks if the car went down in the wind, Alan says, ‘*It went down, yeah, it stuck about halfway*’. Apparently he does remember what happened but when asked if he can say why it stuck halfway he does not reply.

a/b										b	a/b	o												
8;0	10	20	30	40	50	9;0	10	20	30	40	50	10;0	10	20	30	40	50	11;0	10	20	30	40	50	12;0

Alan scarcely participates for the rest of the discussion which lasts just over ten minutes.

Activities

Tilting Gutter										Magnet										Tilting Gutter									
o		e				f		e				b					o		v		e								
12;0	10	20	30	40	50	13;0	10	20	30	40	50	14;0	10	20	30	40	50	15;0	10	20	30	40	50	16;0					

When Alan is asked if he would like to use the Tilting Gutter he says, ‘*Yes please*’. This piece of equipment is no more than a piece of plastic guttering tied to a chair back with a bucket to catch balls rolled down the gutter. It works on similar principles to the activity he had spent some time on at the ISC but is rather different in appearance. Alan appears to know exactly what to do with it, making adjustments to the positioning of the chair and the gutter before rolling the ball. He seems to continue from where he left off at the ISC and soon moves on to another activity (13.55). A fellow-student (Sam) sends him back, he returns briefly, rolls each of the balls, which are of different weights and therefore require different adjustments, successfully into the bucket, then replaces the gutter carefully on the chair seat (16.15).

Dominoes

e	o	\	o	b/e	a	e	o
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16;0 10 20 30 40 50 17;0 10 20 30 40 50 18;0 10 20 30 40 50 19;0 10 20 30 40 50 20;0

When Alan is next on camera he is using the Giant Dominoes. These are the loose dominoes from the science centre with the addition of a lid stuck to one of them: the students were given the additional challenge of setting up the dominoes so that a ping-pong ball placed in the lid would be caught in a plastic pot as the dominoes fell.

o	a	o	a	e	f	e	a
---	---	---	---	---	---	---	---

20;0 10 20 30 40 50 21;0 10 20 30 40 50 22;0 10 20 30 40 50 23;0 10 20 30 40 50 24;0

Alan spends around five minutes setting up the dominoes, occasionally stopping to rub his face, placing them very close together and making sure they are all in line. He places the domino with the lid last in line, adjusts it, places the ping-pong ball on the lid, adjusts its position then slowly pushes on the first domino. The dominoes fall and the ball goes into the pot and is held there by the fallen dominoes. Alan is the first to have achieved this. He looks up, smiles slightly but no one else appears to have noticed and he reacts little before beginning to set the dominoes up again.

a	e	a	b	o	\	a
---	---	---	---	---	---	---

24;0 10 20 30 40 50 25;0 10 20 30 40 50 26;0 10 20 30 40 50 27;0 10 20 30 40 50 28;0

He is distracted for a while (23.35 – 25.40), rubbing his face and scratching, but then goes back to righting the dominoes, pushing them all up together, leaving them once they are upright (26.0).

b	o	b	a/b	b
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28;0 10 20 30 40 50 29;0 10 20 30 40 50 30;0 10 20 30 40 50 31;0 10 20 30 40 50 32;0

After this Alan wanders around the room for around five minutes looking at other things but is discouraged by the others from joining them at anything. He goes over to watch what is happening at the magnet (31.10).

b	\(c)
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32;0 10 20 30 40 50 33;0 10 20 30 40 50 34;0 10 20 30 40 50 35;0 10 20 30 40 50 36;0

When Sam moves away from the magnet (32.40) Alan begins to work there himself. He is half hidden by others but is clearly involved.

x (c)
 36;0 10 20 30 40 50 37;0 10 20 30 40 50 38;0 10 20 30 40 50 39;0 10 20 30 40 50 40;0
x (c) o e o e
 40;0 10 20 30 40 50 41;0 10 20 30 40 50 42;0 10 20 30 40 50 43;0 10 20 30 40 50 44;0

When seen clearly again (42.05) he is trying to connect up a simple circuit which is with the Electromagnet. He kneels at the table and works on this with great concentration. H1 asks if it is working, Alan replies, '*not yet*'. H1 suggests he try a different battery as one appears to be faulty. He is off camera briefly but when he is on again he is successfully completing the circuit with the new battery. It is not possible to know how much help he has had but at this point he is working independently.

e e/f e o a/b b o
 44;0 10 20 30 40 50 45;0 10 20 30 40 50 46;0 10 20 30 40 50 47;0 10 20 30 40 50 48;0

H1 asks again if it is working, Alan replies, '*Yeah*' and smiles across the room (45.15). An LSA comes over and asks, '*How strongly would you say it's glowing, Alan, the light?*' (45.30). Alan does not respond even when this is rephrased as, '*Would you say it's bright or is it just glowing?*'. Alan continues to work on the circuit without looking up through this exchange. He and the LSA are briefly off camera and when they are on again (46.10) the LSA is kneeling in Alan's place touching the circuit, Alan is standing, scratching. The LSA prompts, '*Is it something to do with the battery?*' and Alan replies, '*Well, yeah, yeah ..*', but does not otherwise respond to the explanation of what makes the bulb brighter or less bright.

Comments

Alan again barely contributed to the verbal discussion at the start of the session although he appeared to remember the car that 'got stuck' on the Wind Tunnel slope. During the practical part of the session he worked independently with great concentration as at the ISC, and appeared to carry on where he left off there, making adjustments to reach his goals. He accepted H1's help but ignored the LSA's attempts to teach.

College 2

The second college session recorded for Alan took place seven months after College 1 during Cycle 4 of the research (second year of the main data collection phase). A

group of four students, including Alan, were taken to the college greenhouse by an LSA to pot up tomato plants. Again the finished product was to be sold and this may have had a bearing on the degree of freedom given to the students. The LSA explained that Alan had had a vaccination that day.

a										d	b	a										d	b					a										d
0;0	10	20	30	40	50	1;0	10	20	30	40	50	2;0	10	20	30	40	50	3;0	10	20	30	40	50	4;0														

At the beginning of the video Alan is standing in the greenhouse doing nothing. Sam (a fellow-student, much more articulate and considered more able than Alan) directs Alan to pick up a pot; he does so but then just stands holding it, looking around. Sam takes the pot, Alan stands with his hands in his pockets looking around and smiles briefly at the camera. Sam puts his hand on Alan's shoulder and draws him towards the bench where the tomato plants are. Alan watches briefly with his hands in his pockets but then looks round at the camera, smiles, waves, looks down, then up at the ceiling and down again.

d										a		d					a										d		a
4;0	10	20	30	40	50	5;0	10	20	30	40	50	6;0	10	20	30	40	50	7;0	10	20	30	40	50	8;0					

At 3.50 the LSA directs Alan to move tomato plants from one bench to another, he slowly complies, keeping one hand (the arm where he has had the injection) in his pocket. The LSA encourages him to use it and Sam repeats '*Both hands, use both hands, Alan*' when he goes back to one. Sam suddenly says '*What's this behind you?*' to Alan, Alan jumps back in alarm and the LSA reassures him, saying that it is only a cheese plant and tells Sam that he shouldn't have pointed it out, suggesting Sam may have been deliberately teasing Alan. Alan carries another tomato plant across, Sam points to yet another and hands it to Alan but the LSA says to leave the rest (6.10). Alan stands looking around again, he touches another pot but then takes his hand away, wanders over to the others, scratches his head, looks round the room then down at the bench. He reaches out to touch another student, Richard's hair (there is a leaf in it) and is told not to but a short time later brushes a flower off Richard's back. He returns to looking down until Sam addresses him directly, asking him to set the pots out. He makes to take the pots but the LSA suggests a different size and he looks down again adjusting his sleeve while the LSA and Sam discuss the pots. He makes no attempt to join in their verbal exchange.

a					d	d/e	d	a	d					a										
8;0	10	20	30	40	50	9;0	10	20	30	40	50	10;0	10	20	30	40	50	11;0	10	20	30	40	50	12;0

Alan wanders towards the camera and smiles when he notices it. Sam, having decided which pots to use with the LSA, hands a pile to Alan, saying, '*You can help, Alan.*' Alan takes the

pots, Sam points to the table and says, ‘*Like that*’, then takes pots from the pile, although Alan still has his hand on it, and starts putting them out, saying again, ‘*Like that*’. Alan takes a pot, two come off the pile together and he has difficulty separating them. Sam, not seeing this, shows him again what to do. Alan tries again to separate the pots, Sam reaches out for them, Alan lets them drop and lets Sam carry on, while he returns to doing nothing (9.50-9.55). The LSA comes over (9.55), separates two pots, hands one to Alan and asks him to put it on the table. She then asks Sam and Alan to count the pots. Sam tells Alan to count them then touches each in turn, waiting for Alan to say the number, which he does confidently to nine then more hesitantly to eighteen. Sam reports the number to the LSA (10.55) and Alan stands with his hands in his pockets looking down while the LSA and Sam discuss where to put more pots.

a	b															d					a			
12;0	10	20	30	40	50	13;0	10	20	30	40	50	14;0	10	20	30	40	50	15;0	10	20	30	40	50	16;0

At 12.20 Alan goes over to watch Gemma and Richard mixing compost. When Richard asks if he is going to have a go he doesn’t respond until told to join in by the LSA and then Sam. He uses one hand (perhaps because of the vaccination) until told to use both and takes it out of the mixture again and more or less stops doing anything as soon as the LSA’s attention is elsewhere.

a	d	b	a	a/b	d																			
16;0	10	20	30	40	50	17;0	10	20	30	40	50	18;0	10	20	30	40	50	19;0	10	20	30	40	50	20;0

When the LSA asks someone else to do the mixing, (15.50), Alan stands, brushes down his hands and trousers. Sam takes Alan back to the pots (16.25) and asks him if he is going to start filling them up. Sam demonstrates, Alan watches briefly but then looks away until told specifically by the LSA and then Sam to help with the pot filling (17.30); he then fills pots until 20.30, no longer needing constant reminders.

d	d/e	a					d/e	d					b					d/e						
20;0	10	20	30	40	50	21;0	10	20	30	40	50	22;0	10	20	30	40	50	23;0	10	20	30	40	50	24;0

He stops once to roll up his trouser leg and scratch his knee (20.30 – 21.15) but otherwise continues to fill pots with compost. At one point (21.30) the LSA comes over and shows him how to use a small pot to fill the larger one, encouraging him again to use his left hand too. At 22.40 Sam takes over and fills himself a pot, appearing to think Alan is being too slow, while Alan stands and watches. Alan goes back to filling the pots from 23.10.

d/e	b	d/e	a	d
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24;0 10 20 30 40 50 25;0 10 20 30 40 50 26;0 10 20 30 40 50 27;0 10 20 30 40 50 28;0

He continues to do this with only brief interruptions until 26.30 when the LSA tells him to let Sam take over so that he, Alan, can do some potting up. She talks Alan step by step through the potting up process, including how to make the hole in the compost. She frequently tells him to do something but in fact takes over or takes his hand to guide it before he has time to complete the action, for example when getting the plant out of its original pot or placing it in the new one. She says '*gently or it'll break*' more than once.

d	o
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28;0 10 20 30 40 50 29;0 10 20 30 40 50 30;0 10 20 30 40 50 31;0 10 20 30 40 50 32;0

o	d	a	d	a	b
---	---	---	---	---	---

32;0 10 20 30 40 50 33;0 10 20 30 40 50 34;0 10 20 30 40 50 35;0 10 20 30 40 50 36;0

Alan is off-camera from 30.20 to 34.15 then follows directions from Sam, reinforced by the LSA, to give compost to Gemma. The LSA tells him to come and have his shoelace tied, this done he stands rubbing his face until the LSA brings him over to where she is working with Richard. Once there he pays little attention, watching from time to time ...

b	d	o	x (d)	o	d/e	o
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36;0 10 20 30 40 50 37;0 10 20 30 40 50 38;0 10 20 30 40 50 39;0 10 20 30 40 50 40;0

... until specifically asked to continue filling pots (36.30).

o	d	b	d	a	d	a	o
---	---	---	---	---	---	---	---

40;0 10 20 30 40 50 41;0 10 20 30 40 50 42;0 10 20 30 40 50 43;0 10 20 30 40 50 44;0

Alan continues to fill pots except for the briefest interruptions all the time he is on-camera until the end of the session.

Comments

Alan worked most of the time with Sam, who directed him in a tone which echoed that sometimes used by staff to Alan. Alan generally responded to this direction but as soon as he had carried out the particular task stood motionless, looking around until given further instructions, responding only if these were directly addressed to him. Even when engaged in a task he had been given, such as filling pots with compost, he frequently looked round, smiled at the camera or became preoccupied with his clothes or with rubbing or scratching himself. He had recently had a vaccination and may have been feeling unwell but he in fact

showed similar behaviour when being directed in the other college session or in the ISC.

ISC 2

Alan’s second visit to the science centre took place seven months after his first, during Cycle 4 of the research (second year of the main data collection phase). The students were invited to work at the equipment of their choice without a second introductory session as the equipment was unchanged. Only Alan, Gemma and Richard were present on this occasion.

Dominoes

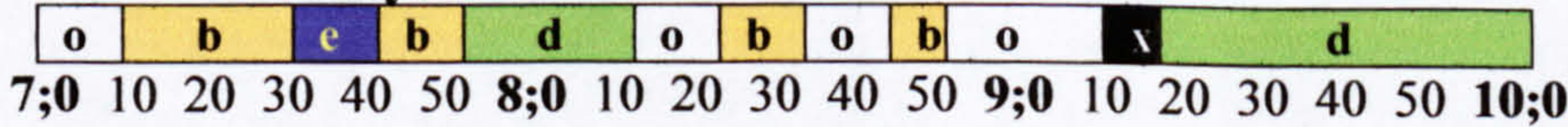


Alan initially joins Gemma and Richard at the Giant Dominoes; here Gemma is very much in charge, telling the other two what to do. Alan sits passively, apparently waiting for her instructions, which he then carries out. Mainly he watches what the others are doing, occasionally seeming to lose interest and looking down at the floor or round the room. He is briefly preoccupied by some problem with his hand. He makes one attempt to help unbidden but this is very brief (1.45-2.00). At one point Richard gives a direction which Alan attempts to follow only to be told ‘No, Alan’ by Gemma, who then gives more precise directions (3.10).

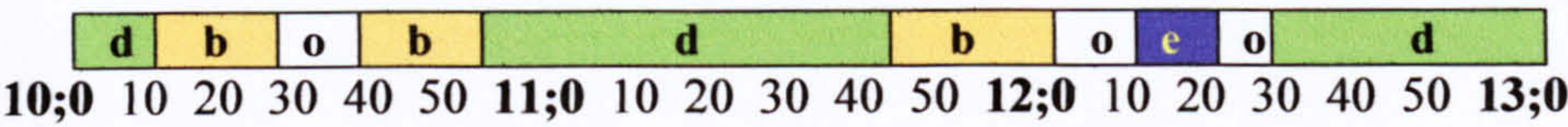


A further attempt to help on Alan’s part is again rejected by Gemma (5.35). After nearly six minutes (5.40) at the dominoes Gemma suggests moving to the Pulleys and tells Alan to come.

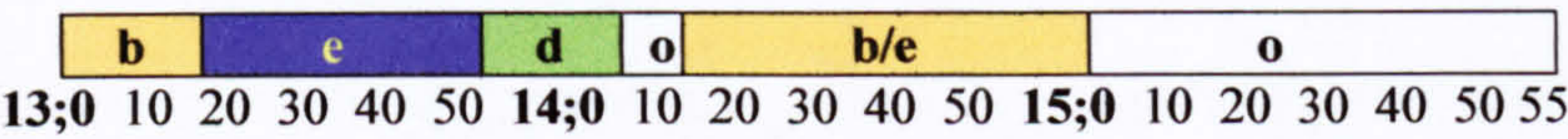
Pulleys



Here too Gemma tells the others what to do. She is placing the ball directly in the gutter rather than using the pulleys and when Alan stretches a hand towards the ropes tells him to put the ball in the gutter, giving precise directions (7.50). When he does so and the ball rolls into the bucket at the other end Gemma says ‘Yeah!’ and pats Alan on the shoulder (8.10).



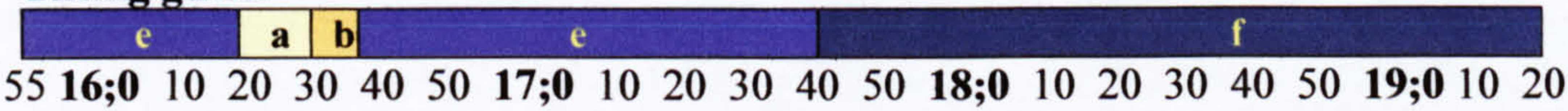
Later she hugs Alan when the ball goes in again (11.20).



For the first fifteen minutes of the session Gemma directs Alan, using a tone that is alternately bossy and patronising, resembling one used to small children - or perhaps one that has been used to her. Alan responds by being very passive, doing only what he is told when he is told. Once or twice he tries again to do things on his own initiative, such as taking hold of the pulley ropes which Gemma has been ignoring (13.15 - 13.50) but Gemma quickly regains control, telling him to wait.

After fifteen minutes H1 suggests to Alan that he might move to another piece of equipment on his own and persuades Gemma not to follow.

Tilting gutter



Alan moves on his own to the Tilting Gutter (15.55) where his level of involvement has immediately increased and he appears to be working to his own goal from the start. His movements, particularly in terms of adjustments of the gutter, appear purposeful and deliberate, on a par with the way in which he was working at this equipment at the end of the previous session seven months before. He appears to have good recall of what to do with it, making fine adjustments, studying the equipment closely, although he still appears unable to use the place where the ball bounces to work out where to place the bucket at first. After two minutes he begins to adjust the bucket more usefully, although still not always in what would seem the logical response to the previous roll.



After approximately eight minutes (24.0) he has brought the bucket very close to the gutter, and seems to be aiming more carefully, tilting the gutter and looking down it before rolling the ball, adjusting the bucket correctly when he misses. His difficulties may have been due to poor eyesight but he may also have needed time to move on to this.



After two more misses Alan stretches (26.10), perhaps beginning to be bored or tired, but then returns to the task, tilts the gutter without letting go of the ball, apparently checking that the end is in line with the bucket, rolls the ball and it goes straight in. Alan cheers.

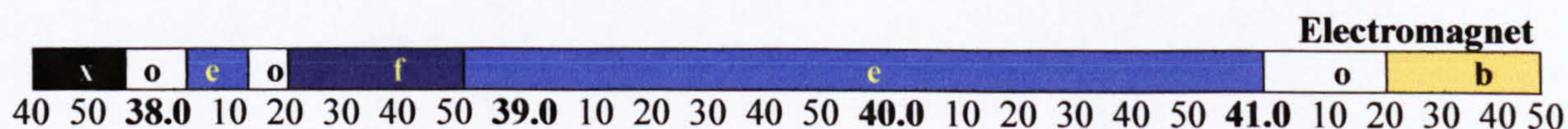
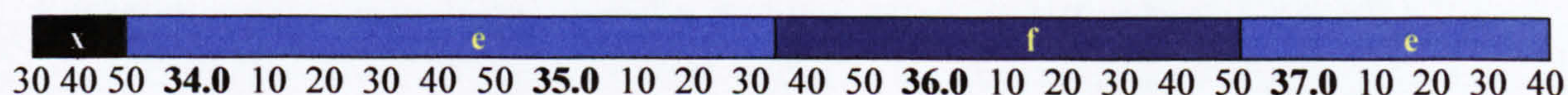


Alan repeats his success a couple of times then moves on (29.0).



Alan moves on to the Motion Detector where Gemma and Richard are working. Gemma suggests moving on to Richard when Alan arrives and they leave. A helper attempts to explain how the Motion Detector works, which buttons to press and how to move to produce the graph on the computer screen. Alan does not respond to her suggestions and appears to find both the language and the concepts difficult, perhaps at least in part because cause and effect are less immediately obvious than with some of the activities. Also it is necessary for the person walking backwards and forwards to watch the screen as they do so in order to understand the effect they are producing. Alan's limited eyesight may make this difficult.

After two minutes (31.10) the helper proposes that Alan should return to the Dominoes. He says 'Yeah' and immediately walks over and sits by them. At first the camera is positioned behind him so it is not possible to see what he is doing in detail but it is clear that he is using the fixed dominoes, setting them up and knocking them down.

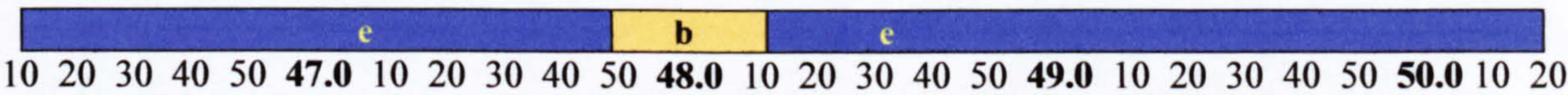


He continues working with the fixed dominoes for nine minutes, apparently with little variation, only briefly making real adjustments to what he is doing. At 40.50 the helper suggests another move. Alan wanders over towards the Electromagnet and off-camera (41.0); thirty seconds later he is standing looking at the magnet. The helper asks him if he

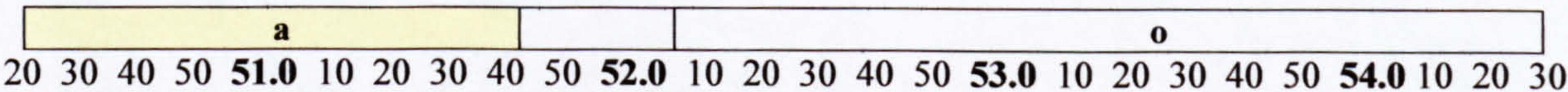
remembers it; Alan replies 'Mm' and sits down, then says, 'Excuse me, can you help me?' (41.45).



The helper shows Alan how to switch on and demonstrates with an iron bar, holding it out to Alan who places it tentatively in the Electromagnet. The helper then shows him what happens if another bar is placed in the other end and the magnet switched on and off, explaining that it works by electricity. Alan replies 'It does, yeah'. His understanding of this is not clear but he certainly appears to understand about the effects produced, which can be directly felt, and here cause and effect are more directly linked than at the Motion Detector. Alan places a metal spoon in one end of the solenoid, touches the switch but then places an iron bar in the other end. The helper asks him if he has switched on, Alan indicates that he has not but that this was deliberate; he looks at her, smiles and switches on (43.20). The spoon and bar are pulled in, Alan pulls and pushes on the spoon, moving the bar with it, then leans over to look into the solenoid at the bar end: curiosity again seems to produce a certain degree of exploration. After playing around with the spoon and the bar a little longer, Alan switches off and takes both out. He picks up a plastic spoon but then rejects it in favour of another metal bar, perhaps aware that the plastic will not be effective.



After studying the instruction card for some time (nearly one minute) Alan says to the helper who is adjusting the camera, 'Excuse me, what's this?' She reads it to him then tries to get Alan to talk about what he has observed, asking for example how it feels when he holds the iron bar in the magnet. He replies 'hard' and later when she asks if he thinks an iron bar will be pulled in he says, 'I think it might be a bit hard' and smiles when it is indeed pulled in. He appears to understand a good deal more than he is able to express in words. He tries the plastic spoon at the helper's suggestion and spends some time moving it around in the magnet, perhaps thinking that it should work as she has suggested it. When she asks if it works, he replies 'Nearly'.



After the helper has moved away (50.20), Alan sits for a moment then switches off, takes the bars out and lays them on the table, gets up and walks off camera (51.40).

Wind Tunnel

b	c	o	e	o	e	f
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40 50 55.0 10 20 30 40 50 56.0 10 20 30 40 50 57.0 10 20 30 40 50 58.0 10 20 30 40 50

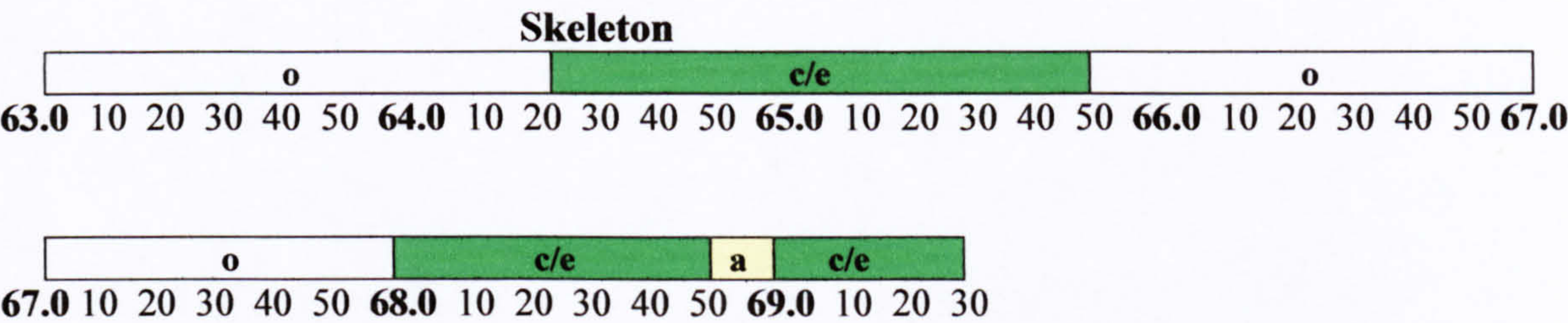
Alan is next seen at the Wind Tunnel where Richard is busy (54.40). Alan looks into the tunnel, there is a brief (inaudible) communication between him and Richard then Alan reaches into the tunnel, looks in and ducks his head, apparently deliberately to feel the wind in his hair (55.0). He is briefly off-camera and when he is seen again he is kneeling in front of the wind tunnel, reaching in for a car, then holds a car in each hand and releases them from different positions on the ramp. A helper brings over the box of card, asking Alan if he remembers it (56.50); Alan says yes but ignores it as he releases the car he is holding into the tunnel. The helper asks if she can take a third car from the tunnel, Alan agrees and continues to run his cars down the ramp as the helper fixes a card 'sail' to the third car. She offers it to Alan who takes it, quickly rolls the car he is holding down the ramp then carefully positions the car with the card, lets go (57.50) and as the car stays at the top of the ramp gestures to it with both hands calling to someone to look. Alan continues to watch the car for nearly half a minute as it moves slightly up and down, then leans across (58.30) and takes a piece of card from the box.

f	g	d	a	d
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50 59.0 10 20 30 40 50 60.0 10 20 30 40 50 61.0 10 20 30 40 50 62.0 10 20 30 40 50 63.0

He picks up a car with a roof, puts it back and selects one with no roof, looks at the first car again, puts it back, sits cross-legged with the second and tries the card against it in various positions. He then holds the car out to the helper who has been preparing pieces of sellotape for him. She asks him if he wants her to fix the card, Alan nods. She fixes a first bit of tape and asks '*like that?*' There is no obvious response from Alan but when the helper holds out a second piece of tape and says something inaudible (due to the noise from the wind tunnel) Alan smiles and nods. The helper fixes the card upright on the second car (the first is still held on the ramp by the wind), hands it to Alan and moves away (59.50). It seems clear from the above that Alan is interested in what is happening to the car with the card on, has a plan for making his own and is willing and able to ask for assistance with the physical aspects that he finds difficult in carrying it out. Alan removes the first car from the ramp and slowly places the second there, smiles (apparently at a second helper) and releases the car which is blown backwards off the ramp. Alan looks up and smiles again, replaces the car and holds it against the wind for one or two seconds then lets go. The car stays at the top of the ramp, Alan smiles up again then reaches out and pushes the car down into the wind. When he lets go the car returns to its previous position, Alan smiles and spreads his hands in a small shrug. It seems that he is curious about why the car stays up, is exploring and sharing the results of this exploration. He pushes the car with his finger again a couple of times then the first helper goes over (61.20) and asks him why the car stays up; Alan smiles but does not reply. She then

asks what he thinks would happen if the wind was turned off, Alan makes a downward gesture with his hand and says 'Go down'. It is apparent that he in fact knew the answer to the original question but difficult to know whether he had had difficulty understanding the question, finding words to answer it, or simply felt it was too obvious to be worth replying. Whatever the case, the intervention has reduced Alan's engagement with the activity.



When the wind is turned off (61.30) Alan sits rubbing his eyes and the helper asks him if he wants to move out of the wind for a bit. Alan agrees but needs specific direction to actually get up and move; this is the first time during the visit since he has been working on his own that he has appeared to need direction to act.

Alan is off camera for less than one minute and when he is seen again (64.20) he is at the Skeleton on the bicycle, turning the pedal. He turns to someone beside him and says, 'He's doing well i'n't he?' There is general laughter and it seems likely that this was intended as a joke. Alan continues to turn the pedal with no apparent goal. When Richard comes over Alan says, 'he's got no skin on it' but this time seems slightly disconcerted by the laughter that follows, stopping what he is doing and looking down for a moment.

Comments

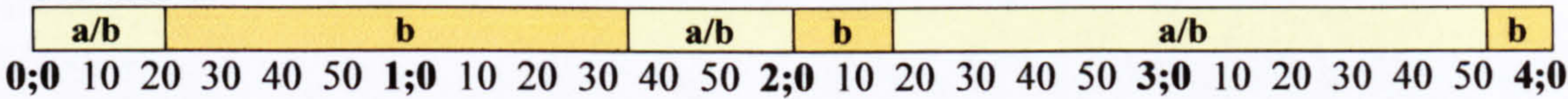
The contrast between Alan's responses when he was being directed and when he was on his own or had requested help was even clearer during this session. He passively followed directions, mostly from Gemma, until he was encouraged to do something on his own (and she was discouraged from following him). He then, as on his previous visit, used the Tilting Gutter with sustained concentration, adapting and adjusting what he was doing in order to achieve his goal. He appeared to find the Motion Detector more difficult, perhaps because cause and effect are less immediately obvious. Again Alan appeared intrigued by what happened to the cars in the Wind Tunnel and this seemed to lead to a small piece of investigation. When he

was asked why the car stayed up he smiled but did not reply, although when asked what he thought would happen if the wind was turned off he made a downward gesture with his hand and said 'Go down'. Any response to a 'why?' question was rare for all the students.

Follow-up 2

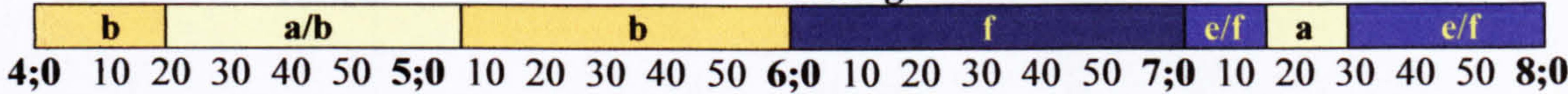
The second follow-up session for Alan took place two weeks after his second visit to the science centre during Cycle 4 of the research (main data collection phase year 2).

Discussion



Activities

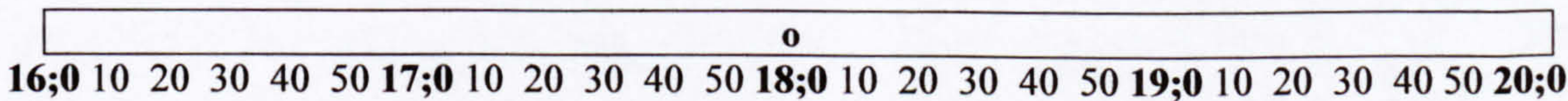
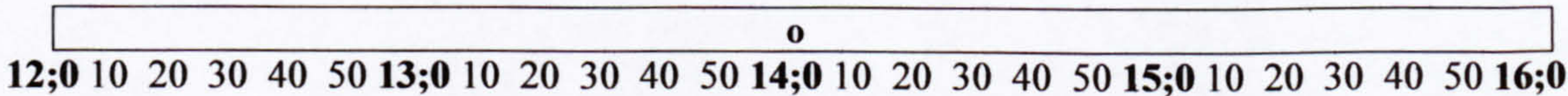
Tilting Gutter



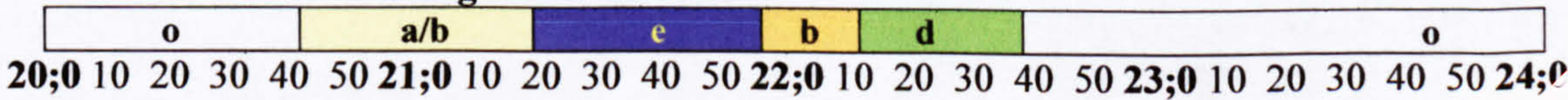
Again Alan is unresponsive during the five minute discussion session but immediately interested in the practical activities. H1 suggests that he might like to go to the Tilting Gutter at the start of the session, and he does so at once.



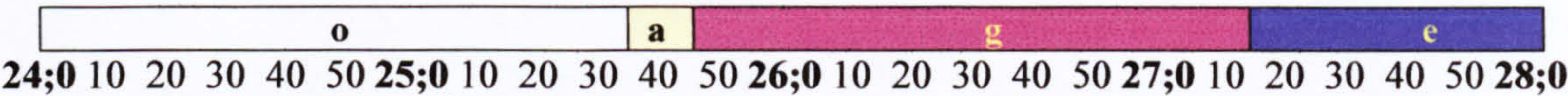
After a single unsuccessful attempt to roll the ball into the bucket, Alan says to H1, *Excuse me, could you pass me the bucket*, (8.20) then directs her in adjusting it until he is able to roll the ball in successfully. He picks up two more balls, rolls them straight in, then, his goal clearly achieved, he spends nearly a minute trying to get the gutter to hang tidily on the back of the chair.



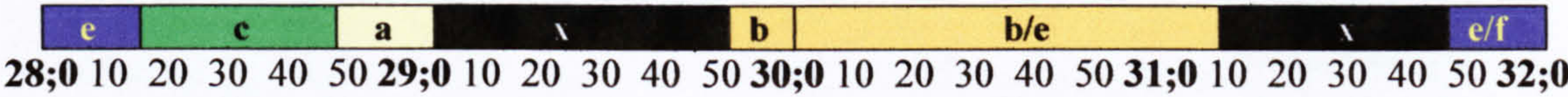
Electromagnet



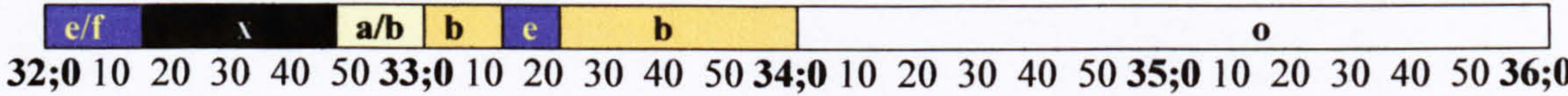
After several minutes off-camera Alan is seated at the Electromagnet and again asks H1 to help. When she asks him if he thinks the metal spoon and then the plastic spoon will work in the magnet he puts them in without answering.



Alan is off-camera again for three minutes; when he is on-camera again he is putting his glasses on and has clearly been trying them out in the solenoid. H1 asks if he wants to try them again and he goes back to exploring whether they will be pulled into the solenoid. When H1 asks if they are being pulled in he doesn't respond.



Alan is joined at the magnet by Richard (27.15). At first Richard tries various things in the magnet ignoring Alan but then they speak to each other (inaudibly) as Richard tries unsuccessfully to use a metal spoon to pull an iron bar out of the magnet. After this Richard picks up a piece of foil or lead which he holds to Alan's face. Alan pretends to kiss it. This is repeated several times to laughter: such playfulness is unusual, particularly for Alan.



They continue to work together at the magnet for the rest of the session (nine more minutes), mainly trying to fish the iron bar out with a spoon. Richard takes most of the initiative and when Alan tries to place his glasses in the magnet again pushes them to one side but Alan is very much part of what is going on and there is discussion and laughter between them about what is happening.

Overall comments on sessions

The contrast in Alan's responses when he was listening to talk and when he was working to his own agenda was again striking in this session. In all sessions filmed he was rarely responsive when listening and hardly more so when carrying out instructions; both in college and in the ISC when being directed he ceased to do anything if not told exactly what to do. When left to his own devices, in the ISC or during follow-up sessions, he was very rarely inactive and needed no

prompting to participate. Language is clearly a difficult medium for him and he appeared to find both understanding and answering questions difficult, tending to avoid this, but a particularly important factor for Alan seemed to be the extent to which he was given the autonomy to do things in his own way.

4.2.2 Gemma

Pen-portrait

Gemma was sixteen at the time of her first visit to the ISC, for the second of the preliminary studies. She attended the same college course as Alan and college records were studied during the third cycle of the research, at the time of her second visit. Her 'statement of special educational needs' noted that she had Down syndrome and also that she suffered from epilepsy. It was stated at the latest annual review of the statement that she was 'a pleasure to teach; industrious with a competitive streak and an unstoppable personality'; her social skills were said to be good. Gemma's statement also noted that she had basic literacy and numeracy skills but found it hard to see their relevance and links to everyday life. She was said to need to increase her ability to write complete sentences and comprehend more of what she read, also to need to improve the clarity of her speech.

Gemma's school science report noted that she tried very hard, was very independent and wanted to try everything; also that she had made excellent progress with written work.

When Gemma's teacher was interviewed, during cycle four of the research, she said she felt Gemma was more mature than when she first went to the college and that previously she had been *'very childish, like a younger girl. She wouldn't do things, she'd have temper tantrums and cry rather than express herself verbally. She doesn't do that at all any more, very, very rarely... she's (inaudible) cheekiness.. No, she's great, she's coming out of herself and she won't behave like a little girl any more...* An increase in Gemma's confidence in general was very apparent between her first and second visits to the ISC. Her teacher also remarked that Gemma enjoyed worksheets but was less confident with practical activities: *'she actually likes working; give her anything to do worksheet-wise and*

she loves it. You don't have to tell her what to do on the whole. Unless it's something practical and she's not quite sure, she'll stop then, but once she joins in (?) she just goes on and she'll help out, she's very helpful'.

Description of sessions

ISC 1

Gemma first visited the science centre as part of the second preliminary study (Cycle 2 of the research); activities were based on Energy and Electricity (see Appendix 1 for description of activities and photographs). Students were given a brief demonstration of the equipment before being invited to choose what they would like to do.

When Gemma is on-camera during the demonstration of the activities she appears to watch but shows no reaction. Following the demonstration, she is seated at the Marble Run; she is seen from back view but is clearly actively involved, manipulating the pieces and the marbles. Occasionally triumphant gestures or exclamations make it clear that she had a goal and that it has been achieved (9.05, 11.35). After a period off-camera (13.0 – 15.50) Gemma is seen at the Water-Lift, watching but doing nothing else; it is not clear whether she has chosen to go there herself nor how interested she is as her response is mainly hidden. At 17.0 Gemma's teacher takes her round to the other side of the Water-Lift; Gemma walks away and off-camera (17.10). She is seen in glimpses at the Heated House for the next three minutes with her teacher beside her but is too far away for her response to be clear (17.10 – 20.20). She is off-camera for nearly ten minutes then at 29.45 is seen going on her own to the Wind Generator but again her response is unclear at this distance. At 30.35 her teacher joins her, Gemma's responses are then clearer and much of what she does appears to be at her teacher's instigation.

From 38.25 Gemma is back at the Marble Run. Her teacher is keen for her to experience other things, however, and asks her if she wants to see the Breathing Skeleton (38.40). Gemma doesn't move and resists the teacher's attempts to take her arm, although she does eventually follow her (39.50). Once at the skeleton Gemma's teacher attempts to use it to explain verbally what is happening and how we breathe. Gemma looks at the ceiling and then at the skeleton but does not respond. The teacher demonstrates blowing up a plastic bag (a subsidiary activity with

the skeleton) then puts it to Gemma's mouth, instructing, *'take a deep breath, take a deep breath. One, two, three.'* And when Gemma doesn't respond, says, *'I'm sure you can do it. Blow, come on ... and blow. Good girl.'* Gemma is briefly off-camera (44.15- 44.45) but the teacher can be heard saying *'There you are, blow, that's better, good ...'* and when the camera is on them again thirty seconds later the teacher is holding the bag to Gemma's mouth and saying *'There, like blowing up a balloon, like at a party. Have another go.'* Gemma averts her head and then shakes it, ducks under the teacher's arm and walks away off-camera (45.10).

When she is next seen two minutes later (47.35) she is at the Water-Lift, which she touches then looks around then at 47.50 she moves of her own accord to the Circuit Tables. Her teacher calls, *'Gemma!'* but Gemma ignores her; she squats by the table and immediately seems very focused on what she is doing; slowly and carefully connecting the circuit to make the spinner turn. Staff exclaim at what she achieves or come up beside her to demonstrate other possibilities but all are ignored and Gemma works with concentration and a clear goal for over four minutes (47.45 – 51.20). At this point H3 goes over and tries to engage Gemma's interest in the electricity meter, explaining its function verbally. Gemma stops what she is doing and watches. Her response is hidden at first by the helper (51.20-52.40) but when it can be seen her body language (kneeling low, away from the table) suggests lack of interest. At 52.55 the helper is called away and Gemma kneels up again, disconnects the circuit and looks around the room. She is off-camera for over six minutes (53.50 – 60.35) then can be seen at the other Circuit Table with an LSA; she appears interested but is too far away for the LSA's input or Gemma's response to be clear.

The session ends with a 'Scientists' Conference', as for mainstream groups, with H1 leading a discussion, encouraging students to talk about what they have done. Gemma takes no part in this, except to form part of a circle to see if the tiny current from the Transistorised Light Box will pass through the whole group to light the bulb and even when it does she shows little enthusiasm.



Gemma (in red by the skeleton's head) watching a demonstration of the skeleton's 'lungs'



Gemma connecting circuits

Comments

Gemma appeared to dislike being told what to do (although her very negative response to the skeleton could perhaps have been exacerbated by a dislike or fear of skeletons). She showed real enthusiasm for the Marble Run and the Circuits and, particularly in the case of the latter, she showed understanding of what she needed to do to achieve a goal. As soon as staff attempted to explain something verbally she became passive, looking down or away, or actively avoided the explanation. This was one example that led to the original hypothesis that students responded to non-verbal but not to verbal input. Gemma played no

part in verbal exchanges during the 'Conference' and appeared, like Alan, to find language a difficult medium.

Follow-up session 1

The first follow-up session for Gemma also took place during the second of the preliminary studies (Cycle 2 of the research), six weeks after her first visit to the ISC.

The session begins with discussion round a table (0-8.05), H1 is asking students what they remember about their visit, using photographs taken by the teacher to prompt recall. Gemma does not respond even when addressed directly. She still does not show any response as the equipment is set out and she is given the Transistorised Light Box, then the teacher says '*Ooh, Gemma, the Helter Skelter* (Marble run)' and Gemma responds '*Yeah!*'. She is asked if she wants to start with that and replies '*Yes*' without hesitation.

Gemma works collaboratively with another student (considered more able) and participates fully, frequently taking the lead, making adjustments where necessary, commenting on what they are doing, apparently happy to talk once the pressure to do so is removed. Gemma is actively involved for over seventeen minutes until H1 suggests changing activities (27.15). The Marble Run is moved in order to give others a turn and Gemma is again offered the Transistorised Light Box (because she had shown such interest in the Circuits at the science centre); she puts her head down on the table (27.20). Gemma is persuaded by her teacher and the other student to join in trying out the Light Box, including placing the wires on her fellow-student's tongue! Gemma carries out their suggestions but never shows the same involvement she had with the Marble Run. When H1 asks her if she thinks the iron bar will make the lamp light up (i.e. complete the circuit), and tries to help her test this (39.35) she shows some of the avoidance of activities initiated by staff that she had shown at the ISC, turning away. At 39.55 Gemma leans across to watch what others are doing at the marble run and from this point to the end of the session is half off-camera.

Comments

Gemma took no part at all in the discussion section of this session. She was animated when carrying out the activity of her choice but not with the activity she had not chosen. She co-operated with her teacher and fellow-student's suggestions for using the Light Box but actively avoided my attempt to further engage her attention.

College session 1

The first college session recorded for Gemma took place during the first year of the main data collection phase (Cycle 3 of the research). She was in the same group as Alan, making Christmas cards for sale later in the term.

The first half hour of the session consists mainly of the teacher talking and asking the students what they remember about the previous lesson. Gemma answers when directly addressed, usually with one word, for example; Teacher: *Did you cut any squares, Gemma?* Gemma: *Yeah.* (1.40). And two minutes later (when another student can't remember the word): Teacher: *Gemma, what shapes did you cut out for your card?* (points to Gemma's folder) Gemma: *Squares.* Otherwise Gemma sits silently looking at the speaker or down at her folder. Later (4.50) she puts her hand up when another student is being questioned but goes back to looking at her folder when she isn't asked to contribute. She again puts her hand up and participates briefly on several more occasions when the teacher asks what equipment the students will need for making the cards.

Gemma clearly remembers what they did in the previous lesson and is keen to show this, although she does not always seem to make the right guess at what the teacher is thinking: Teacher: *If I were to say paint, press, pull, what would you think of?* Gemma (putting both hands up): *Ooh!* Teacher: *Who can remember doing paint, press, pull the other week?* (Gemma waves her hand) Teacher: *Gemma can. What were we doing?* Gemma: *Pull* (mimes pulling) Teacher: *Yes, what were we doing when we did paint, press, pull?* (Gemma repeats pulling gesture and says something inaudible). Teacher: *Sorry, I didn't quite catch that.* Gemma: *Sponge?* Teacher: *Sponging off you're thinking of? Yes, we did do sponging off. That isn't what I was thinking of. Do you remember paint, press and pull?* Another student says 'stamp' (the right answer) and the teacher turns her attention to him. The teacher continues to elicit from the students what they did last session and what they will need for this session for a further seven and a half minutes. Gemma contributes only once more (16.20), to add glue to the list of equipment they will need, mostly she is looking down, head in hand, and it is not possible to tell whether she is attending or not.

The teacher invites the pupils to estimate how many cards they will be able to make that lesson. Gemma is invited to guess first and says fifty (21.55). She appears more interested when the

others are guessing but after a while her interest appears to be waning (26.10), she picks up her pencil case and looks in it, although she may still be listening. Gemma participates again when the teacher is once more re-capping step by step what they did last time and what they are going to do: Teacher: *Right, draw round. And they were squares, weren't they?* Gemma: *Yeah.* Teacher: *Then what happened, Gemma? What happened after you'd drawn round the squares?* Gemma: *Cut it out* (28.30-28.45).

The teacher explains that the card making will be like a production line with each student carrying out a small part of the process. She allocates the job of sprinkling on embossing powder to Gemma telling her it is an important job as the powder mustn't be wasted. Gemma looks at her while she says this (32.40 – 33.20) then down again (33.20-34.20). For the next fourteen minutes (34.40-48.40) staff are helping students get their equipment ready. Gemma follows directions concerning the setting up of the equipment (34.40-36.10), she adjusts her equipment occasionally once it is out but mainly just waits silently unless she is being told what to do until Darren (another student, working next to her) initiates conversation (42.00) . Gemma is slow to respond to him at first but then does so quietly, although she ignores his attempts to make her laugh by saying 'boo' (42.00-48.40).

Gemma makes no attempt to begin work until the teacher has joined them but becomes more involved once the teacher is there (48.40-61.40). Gemma works with great concentration, tongue out, nevertheless the teacher frequently directs what she is doing step by step. Only rarely is Gemma working independently and even then she is carrying out the steps exactly as she has been directed.

Comments

Gemma was eager to contribute what she remembered from the previous session, although her participation diminished when she did not appear to have come up with the answer the teacher had in mind. In the practical session she took very little action (two minutes out of thirty) without being specifically directed.

ISC 2

This was Gemma's second visit to the ISC, her first in the main data collection phase (Cycle 3) with activities focused on Forces and Movement (see Appendix I). The Water-Lift had been retained from the previous year.

During the introduction (0-5.10) H1 demonstrates the Water-Lift which Gemma has seen before, Gemma watches intently and continues to show interest as H1 demonstrates other equipment but when H1 says, '*This is our clown, would you like to do something for me, Gemma?*' (i.e. hit the drum) Gemma says, '*No*' (2.10).

At the end of the introduction (5.10) Gemma is invited to choose an activity by her teacher and moves off-camera (5.30). She is seen briefly at the Giant Dominoes (6.20-6.30) then off-camera again. At 8.50 she is still at the dominoes, lining up loose dominoes with care. She places one at the front of the line, causing them all to fall but smiles at H1 rather than becoming frustrated. She calls and beckons to someone (probably her teacher) (11.0) then claps her hands, smiles and bounces up and down on her knees. Gemma mimes knocking the first domino, indicating anticipation of what will happen, then knocks it. All the dominoes fall to applause and Gemma smiles and bounces again on her knees, clearly enjoying having an audience, before beginning to set the dominoes up again. Richard comes to watch then helps her to set the dominoes up. She tells him where to put them, placing her own alternately, correcting him if he doesn't do it her way, bringing his attention back if it wanders. When all the dominoes are upright, Gemma points at the first one and says to Richard, '*Go on, you do it*'. Richard hits the domino, they all fall. Gemma says '*Well done*' and applauds. The teacher then intervenes (13.45) and tells Gemma to let Richard do it on his own. Gemma moves aside and is off-camera until 16.20. When she is seen again, she is still sitting by the dominoes, while the teacher working with Richard. She is not doing anything and shows no particular interest in what they are doing; she appears to have made her own domino set-up and to be waiting for the teacher's attention. The teacher speaks to her and gestures at the dominoes, Gemma knocks them and they fall apart from the last one. The teacher asks her if it worked and Gemma says, '*No*'.

At 20.05 Gemma is still at the dominoes, talking to Richard, she beckons to a member of staff who suggests she should try a different activity. Gemma asks Richard (very slowly and deliberately) what he wants to do, offering him a choice but then beckons to Alan and remains at dominoes with them both. Gemma is off-camera for four and a half minutes (22.20-26.55) then seen briefly at the Pulleys placing the ball in the gutter by hand and cheering when it rolls

down into the bucket on the spring. She is with an LSA but interactions between them are not clear.

Comments

Gemma showed interest throughout the visit and most of the time appeared to have a clear goal in what she was doing but seemed happy to work repetitively, mainly with the dominoes. She had changed considerably since the preliminary visit eight months previously, clearly now enjoying directing others and tending to talk to them in a somewhat patronising way, as if to a small child (possibly reflecting the way she has been spoken to).

Follow-up 2

The second follow-up session for Gemma also took place in the first year of the main data collection phase (Cycle 3), three weeks after her second visit to the ISC.

The first twelve minutes of the follow-up session are spent in discussion. Gemma says she remembers the visit to the science centre but doesn't respond when asked if she remembers some of the things she did there. She nods when H1 asks if she remembers the dominoes but doesn't say any more about these, although she does ask why the length of gutter is attached to a chair. H1 suggests Gemma should start with the Giant Dominoes (10.45). Gemma suggests placing the dominoes on the table rather than on the floor and when this is done (12.20) begins to set the dominoes up and then to direct Richard to help when he joins her. Gemma asks about the ping-pong ball (additional feature) and H1 explains that she thought if they put the domino with the lid at the end and the ping-pong ball on the lid it might be possible to catch the ball in the pot when the dominoes fall. She asks Gemma if she thinks she could do this, Gemma doesn't respond but directs Richard to continue aligning the dominoes.

When they get to the other end of the row, Gemma adjusts the domino with the lid and places the ball on top (17.05). The camera is off briefly at this point and when it is on again (17.10) another student (Alan) has come over to the dominoes. Gemma asks H1 if they can swap and takes Richard by the wrist to lead him to the Tilting Gutter, prompting Alan to say '*She loves you, Richard*', Gemma doesn't respond. She is immediately involved at the Tilting Gutter but

exactly what she is doing is unclear as she is half off-camera (17.40 – 18.45). Once she is on-camera again it is clear that she is rolling the ball down the gutter aiming at the bucket. It misses the bucket and Richard retrieves it, Gemma says '*Do it again*' and holds the gutter horizontally while Richard places the ball on it. She tilts it, the ball misses again, Gemma and Richard say '*Aah*'. Gemma tilts the gutter towards the bucket, apparently checking the angle, while Richard is retrieving the ball (19.30) but does not adjust the bucket which is very close. Richard returns and rubs the ball on Gemma's head; she tells him not to and beckons H1 (19.45). H1 asks if the ball is going in, Gemma says, '*No*' and rolls the ball again which falls on Richard's feet, Gemma repeats with the same result and Gemma and H1 laugh

H1 suggests sorting out the bucket; this is ignored by Gemma who tells Richard to watch; she rolls the ball, again onto Richard's leg. H1 asks Gemma if she can make the ball go in the bucket (20.55), she says '*No*' and Richard says *he's* the bucket (rolling the ball onto Richard's feet, which began as an accident has developed into a sort of game, although the ball, which is hard, clearly does hurt Richard a little). Gemma rolls the ball, again unsuccessfully. Richard and H1 move away, Gemma, clearly wanting to remain in charge, tells them to come back (22.00) and beckons. She then demonstrates pointing the gutter straight at the bucket; H1 asks her what she thinks will happen, Gemma says '*Go in*'. She rolls the ball again but raises the gutter as she does so, so the ball falls on Richard's feet again, although it is not clear whether this was deliberate or not. H1 suggests changing to a soft ball to save Richard's feet then asks Gemma why she thinks the ball is going on them and not in the bucket. Gemma responds '*Won't go in*' and H1 says, '*Maybe you need to move the bucket*'. Gemma says, '*Yeah*' but doesn't do so, she does, however, change to a soft ball (22.40).

At 27.00 H1 invites Gemma to have another go with the dominoes and Gemma moves rapidly over to them. She begins to use the dominoes, leaving them set up as they have been left by Alan, very close together. She adjusts the plastic pot, looks closely at the ping-pong ball and pot then hits the domino at the other end; all the dominoes fall and the ball goes in the pot. Gemma raises her arms in triumph (27.30). H1 says '*brilliant*' but then asks Gemma if she could do it with the dominoes further apart; Gemma ignores this. A little later (28.20) Gemma perceives a problem (the lid has come off the last domino) and does respond briefly to suggestions from H1 to remedy this, then asks Richard to come and help her (28.55). Gemma is again in charge, setting up the dominoes, resisting attempts by another student (Sam) to change places (29.55) and later resisting his attempts to help adjust the plastic pot (32.45).

When all are set up, Sam tells Richard to push the first domino but Gemma says *she* will; the ball just misses the pot (37.25). H1 asks Gemma to let Sam have a go as he has been waiting for some time and Sam and Richard plead with Gemma. She continues to refuse but then agrees to allow him to after one more turn and, when the ball has just missed the pot again, keeps her word (39.05). Gemma asks Richard which activity he likes and he says the magnet but after a few seconds of watching Alan there she persuades him to return to the Tilting Gutter. They are off camera for several minutes and when seen again Gemma is still in control at the Gutter, aiming more carefully and successfully than previously. When Sam comes over, Gemma and Richard move away (48.0) and the session ends.

Comments

Gemma was actively involved throughout and in charge for most of the time. She took on the new challenge of the ping-pong ball and was able to participate in adjusting the pot at the end of the dominoes to catch it with some scaffolding but rarely made adjustments of her own accord. She tended to direct Richard and both appeared to enjoy a slightly flirtatious relationship. She was as resistant to Sam taking over as she was to adult intervention.

College Session 2

The second college session recorded for Gemma - potting up tomato plants in the greenhouse - took place, as for Alan, in the second year of the main data collection phase (Cycle 4).

Gemma appears more confident than on the previous occasion in college. At the start when the LSA complains that the compost is heavy Gemma jokes '*Like W*' (LSA's name). The LSA later jokes with Gemma and clearly they have a good rapport. Gemma follows directions, filling a bucket half with compost half with peat, then mixing with her hands. She is working with Richard and brings him back to the task from time to time when his attention wanders, directing him. She completes each section of the task without prompting then waits for the next instruction (0.45-13.55). Two other students have a turn at mixing while Gemma watches (13.55-15.00) then Gemma and Richard return to filling the bucket, Gemma telling Richard

what to do. Richard appears more interested in Gemma than in the task and they chat to each other as they work.

Twenty minutes into the session the LSA offers Gemma the opportunity to change jobs; Gemma says she is happy with what she is doing. She is now working independently most of the time, not now awaiting instructions at each stage, although continuing to perform the very simple task that she has been set. After thirty minutes Alan joins Gemma and Richard, and, at the LSA's request, Gemma explains to him what he has to do. After nearly thirty-six minutes Gemma is still working at this task and has been joined by Sam. When the compost is finished Sam goes to discuss this with the LSA and Gemma wanders outside (40.00). The LSA tells her to come in again and asks if she would like to have a turn at potting up. Gemma moves across then waits to be told what to do next (41.35–41.55). The LSA guides her through the potting up process step by step, Gemma follows directions but does very little on her own initiative; for example when invited to choose another plant to pot up, asks, '*which one?*' although she has done it before under the LSA's guidance. At one point (46.10) the LSA says, '*I'll put more dirt round, otherwise when you put more water on it, what do you think will happen?*', Gemma doesn't respond.

Comments

Gemma appeared more relaxed than in the previous college session over six months previously, and seemed more mature and confident. Much more time was spent on practical tasks in this session, nevertheless very precise directions were given and there was very little real choice (again the end product was to be sold). Gemma carried out the directions independently but at first waited at each stage for further directions; after a while she passed on directions to others still carrying out the task precisely as set. She was reluctant to change tasks and when she did so again waited for step by step directions. She didn't respond to the LSA's question about what she thought would happen.

ISC 3

Gemma visited the ISC for a third time in the second year of the main data collection phase (Cycle 4).

The students have been invited to choose an activity at the start of the session, there is no introduction as they have already encountered these activities. At the start of filming Gemma is already at the Giant Dominoes, Richard and Alan are beside her but not participating at this point. Gemma is setting up the dominoes that are fixed to a board which has been propped on boxes the opposite way round to usual so the dominoes are tending to fall back down as she puts them up. H1 suggests moving the box so the board is flatter (1.20), Gemma ignores this but when Richard makes the same suggestion (1.50) she responds, asking him to hold the board while she removes the box. Once this is done she continues to set up the dominoes, pushing Richard's hand away when he tries to put one up in the middle (2.20), showing him how to set them up in order. Richard tells Alan to help (2.55) but when he reaches out to a middle domino, Gemma says '*No, Alan*' and both Gemma and Richard point to the next in line. Gemma then instructs Alan step by step, saying, '*This one, Alan*' (Alan puts it up), then '*That's it, Alan, then this*'. After being briefly distracted by Adam's sore hand (3.20-4.0), Gemma continues to organise the others and when she is satisfied tells them to move away (4.10) and to watch, then hits the domino at the wrong end (the plank is still the opposite way round to last time she encountered it) but immediately corrects this. When the dominoes have fallen (4.40) Gemma sits back on her heels and asks '*What now?*'

At the Pulleys Gemma is again very much in charge, indeed 'bossy'; for example when Richard goes to fetch the ball she claps her hands and says '*Be quick!*' When Alan tries to use the pulley to raise the bucket with the ball in – the original intention behind the activity - she tells him to place the ball straight in the gutter, saying, '*No look, ball there, along there*' (runs finger along gutter), '*down there, into there. Alright?*' And, when he succeeds, pats him on the shoulder, looking up into his face and saying '*Well done, Alan.*' in a tone generally reserved for the very young. When Richard tries to walk away (8.25) she calls him back and slightly alters the activity, organizing the other two in the manner of a playground game: '*Richard, take two balls ... one each ... which one first, you or Alan, you or Richard? Which one, quick*'. When Alan's ball goes in the bucket, Gemma says, '*Yeah!*' and puts her arm round Alan's shoulder, to which he responds with a kiss and Richard says '*Aah*' (11.30). They continue to roll the balls down the gutter in turn until 15.00, Gemma very much maintaining control; if one of the others attempts

to stray from her agenda she calls them back into line; when Alan takes the pulley ropes again at around 13.00 she tells him he can do that in a minute. Gemma only very briefly adjusts what she is doing to achieve the goal she has set (getting the ball down the gutter into the bucket): when one of the balls sticks she shows she understands the need to give it a harder push the next time (14.30). At 15.00 Alan moves away, Gemma calls '*No, no, Alan*' but is ignored. She then wants to follow him to the Tilting Gutter but is persuaded not to by H1. Gemma and Richard move off camera.

Gemma and Richard are next seen at the Motion Detector (18.00). Gemma begins to read the written directions which explain which keys to press to set the Motion Detector going but the screen becomes frozen. She calls to Alan but H1 comes over and offers to help re-set the computer. H1 tells Gemma which keys to press one by one, then Gemma does it on her own while H1 gets Richard to move in front of the ultrasonic beam. Gemma then takes over, telling Richard to come back and H1 moves away (20.15). Gemma succeeds in re-setting the computer but neither move, missing the point of the activity. They hold an inaudible consultation, perhaps bored with this activity, Gemma finds a pencil (25.20) and spends the next four minutes instructing Richard in writing his name. They are not engaged in the activity envisaged by the organisers but are nevertheless engaged in their own activity using the materials provided. At 29.20 Gemma returns her attention to the computer keyboard and directs Richard in resetting, which he does successfully and makes as if to move; she tells him to wait and they watch the screen together until the time runs out when Gemma says '*Nearly!*'. At 29.30 Alan comes over and Richard suggests changing activities. They go to the Tilting Gutter.

Gemma asks Richard about the gutter and when he says, '*The ball goes on there,*' replies '*Well done*' like a teacher who was looking for a particular answer. She proceeds to direct Richard to take turns in placing the ball on the gutter but she maintains control of tilting the gutter. It does not seem to occur to either of them to move the bucket but Gemma is clearly varying the tilt of the gutter and once achieves her aim by holding the ball while she tilts the gutter then letting go when it is in place (33.55). At 35.30 Gemma does move the bucket and the ball now falls beyond it. She adjusts the tilt of the gutter, aligning it with the bucket before allowing Richard to place the ball but still the ball falls beyond the bucket. Gemma announces that this will be the last one and when the ball misses again Richard brings it back and drops it in the bucket by hand and they move away and back to the Pulleys (37.40). Neither has shown frustration at failure; Richard has allowed Gemma almost complete control.

Gemma shows interest in the ropes attaching the bucket to the pulley system which she had ignored previously. They are tangled however; she clearly perceives the problem and tries to sort the ropes out but not very successfully. She pulls the bucket up using the green rope designed to tip it so it is upside down (39.25). Again she is aware of the problem and lowers it a little then holds it upright and tells Richard to put the ball in. Richard places the ball directly in the gutter as Gemma had done previously but Gemma remonstrates with him and again when he tries to take the rope. One of the ropes has come right off the pulley, H1 comes over and offers to rethread it (40.10). This is accepted and Gemma pulls the bucket up still using the green rope. She raises the bucket to the gutter then asks, '*What do you think? Back down?*' but lowers it to the ground before Richard has a chance to reply. Richard suggests moving to another activity.

Gemma goes to the Magnet (43.45) but then decides to join Richard at the Thump Wave Clown, immediately taking a turn. She taps the drum rapidly and quite gently with no discernible effect on the clown. H2 comes over and demonstrates (44.10), both then hit harder but Richard more effectively. Richard tries to demonstrate to Gemma but she moves away after two minutes (45.40).

They are seen again by the Skeleton on the Bicycle; Richard swings the Disembodied Leg and Gemma asks '*What's this?*' He replies '*That's a leg*' and Gemma says '*Well done,*' again as if she was testing him. H1 comes over, takes some string from the box and says they can use it to make the leg kick if they want to (i.e. by attaching it to the lower leg) (46.30). Gemma takes the string but uses it to 'measure' Richard. Richard submits to this for approximately one minute then reaches across and swings the leg again. Gemma ties the string round the upper (immobile part of the leg). H1 returns and asks Gemma if she thinks she could tie the string to the hook and use it to make the leg kick, explaining that it's like the muscles on a leg. Gemma ties the string on though not looking at what she is doing then swings the leg for nearly two minutes by holding the hook not the string (it is unclear whether this indicates lack of interest or a literal understanding of H1's suggestion). At 51.00 she goes to look in the box and, finding a tape measure, returns to measuring Richard, he submits but is clearly getting tired of this activity. Two minutes later H1 invites Richard to go to the Wind Tunnel in a deliberate attempt to split them up to see what Richard will do on his own. She invites Gemma to show her what she was doing at another activity but Gemma does not move. The camera follows Richard.

At 62.10 Gemma comes over to where Alan is using the Wind Tunnel. H1 asks her if there is anything she hasn't done yet that she would like to do, she points at the Wind Tunnel. She takes Alan's place and rolls three cars one by one down the ramp. She seems puzzled by the fact that the third car doesn't go down, although it appears simply to be blocked by the other two, she tries again slightly altering what she is doing but still appears puzzled that they will not all three go down. She removes the cars and picks up the sellotape then takes the box with the card and sellotape away. The session ends at this point.

Comments

Gemma appeared more than ever determined to remain in control, particularly in relation to Richard, although she often seemed to miss the point of an activity and was stopping him from using it in a more interesting way. The Motion Detector in particular is relatively difficult conceptually; cause and effect are not as obviously linked as in some activities, movement within the box on the floor produces lines (graph) on the screen. Gemma set her own goals, sometimes unrelated to the activities themselves, such as teaching Richard to write his name, but when working with the equipment rarely made adaptations to achieve them. She showed she had some idea of the adjustments needed, for example for the Tilting Gutter, even if these were not very effective. She showed no frustration when goals were not achieved. Gemma spoke to the other students (Richard and Alan) as if they were much younger or less able and there are echoes here of the way in which she was spoken to by her teacher on her first visit.

Follow-up 3

A third follow-up session for Gemma took place two weeks after her third visit to the ISC during the second year of the main data collection phase (Cycle 4).

The session again begins with discussion about what the students remember of their visit to the ISC. Gemma contributes almost nothing even when directly addressed. H1 asks if she and Richard remember what they did there (2.05) and at first only Richard responds, talking about the dominoes. H1 asks if they remember anything else and Gemma says, *'That'* (Tilting Gutter): H1: *And what did you do with that?* Gemma: *Get a ball and ...* (inaudible) H1: *Right, and where did the ball go?* Gemma: *In the tube then the ball go in the bucket.* H1: *Right. Did you manage to get it in?* Gemma: *Yeah* (smiles). This is the extent of Gemma's contribution to the discussion but as soon as H1 begins to talk about the activities she has brought with her (5.35). Gemma becomes more animated and starts to arrange the dominoes (5.55). She says *'What's this?'* (the jar lid has come off the last domino) then sticks the lid back on, solving the problem herself this time. She places the ping-pong ball on it then carefully places the domino on the table and continues to give Richard instructions but when she looks away he knocks a domino so they all fall. Gemma gives him an exasperated but smiling look. An LSA intervenes with, *'Look what you're doing, if you look what you're doing you'll be able to see. It's no use smiling at each other like that, come on concentrate'* and, although they appear to have been concentrating up to this point, they are briefly distracted 14.25 – 14.35. Gemma lines the dominoes up again then adjusts the plastic pot, saying *'It's got to go in there, alright?'*

H1 asks Richard if he wants to go to the Tilting Gutter, Richard goes with her, Gemma continues lining up the dominoes on her own then is off camera (16.20). When she is on-camera again she is at the Tilting Gutter (22.40), rolling the ball which falls in front of the bucket. Gemma asks politely for the ball, H1 retrieves it. Gemma carefully positions the ball, checks the slope of the gutter, then rolls the ball which bounces on the rim of the bucket. H1 retrieves the ball and asks again *'What do we need to do to make it go in Gemma? What do you reckon?'* The LSA says *'It did go in, didn't it, Gemma?'* Gemma ignores them both, holds the ball on the gutter and adjusts the angle. Richard comes over and H1 asks Gemma if she wants him to help, she says, *'No'*. At 23.45 the LSA comes over, adjusts the bucket without saying anything and tilts the gutter towards the bucket. Gemma rolls the ball which goes straight in; she gives a gesture of mild triumph, almost an ironic shrug. The LSA takes three balls from the bucket and gives them to Gemma. Gemma rolls a ball without looking at what she is doing. The LSA adjusts the bucket slightly as the ball falls but it still misses, she and Gemma make sounds of disappointment. Gemma continues to roll balls handed to her by the LSA, who continues to adjust the bucket but Gemma doesn't seem to be paying much attention, not looking at the ball as she rolls it, looking briefly across the room several times. At 24.50 LSA retrieves the ball

then is called away, Gemma waits not doing anything for a further minute when the session ends.

Comments (all sessions)

Gemma changed over the period of the study, becoming much more confident and relaxed, keen to teach others and to be in control. She continued to appear to enjoy fairly straightforward, repetitive tasks however, such as filling the bucket with compost. At the ISC she continued to set herself a task and carry it out but was not innovative. Her understanding of what was happening, and therefore what adjustments she needed to make to achieve her goal, was not always clear.

4.2.3 Karen

Pen-Portrait

Karen was thirteen at the time of her first visit to the ISC. She was in a Key Stage 3-4 class of a special school designated for pupils with SLD. This class was based on a mainstream secondary school site with integration in a limited number of mainstream classes for some students; for Karen this took place in registration, RE and break times. Karen's 'statement of special educational needs', dating from two years previously noted that she had Down syndrome, that her vision was within normal limits, that she had good body and spatial awareness but a history of middle ear dysfunction; she wore bi-lateral hearing aids.

Karen's school report for the second year of the study, when she was fourteen, noted that she was eager to participate in group discussions but needed prompting to slow down and think about what she wanted to say. She was also said to need prompting to concentrate and was easily distracted. A target at that time was to continue to improve her concentration when listening. The report also noted that she chatted with fellow students and played independently and imaginatively with others but liked to take control and needed reminding to listen and share; she was working on collaborative working skills. A further target on Karen's report was to build up her awareness of speech sounds and vocabulary. In reading, the use of symbols was being reduced and phonics started; she was said to have good intonation when reading and it was noted that she was doing some writing. She was described as using maths in a practical setting, for example counting the number of students in class on a given day and that she was able to order and add to twenty and use coins up to one pound. In science it was noted that with help she could sort solids, liquids

and gases and with prompting list their properties. With a little help she was said to be able to set up an experiment. She was able to identify when a liquid was boiling by observation and use of a thermometer but was said to find drawing conclusions difficult. It was noted in the report that she enjoyed visits to the ISC and that she needed no prompting to explore and try the equipment there.

Karen's teacher, watching the videos of Karen at the ISC, recognised that she responded differently in different settings:

Oh, there's Miss B (Karen), she's loving it, she's got such a good investigative nature, wherever you take her she's enthralled, she's interested ...Look, she knows exactly what she's looking for.

She said that Karen's concentration was good in this situation but that

she wouldn't be able to sit in a group, she goes off after, you have to bring her back, but this is active, isn't it? And she's interested. Look at the way, I mean she's genuinely in .., the enthuse .. you know, her face. She knows, doesn't she? I mean she's, why is it happening, why is it going down? .. There we go. That's brilliant isn't it? She's accepted that something doesn't work and is not prepared to walk away, she's going to do it until it's .. I mean her concentration here is wonderful but she is good at, she does enjoy anything more practical, she doesn't maybe, she finds the listening quite difficult, she does want to do ... That is wonderful that she's not giving up, I mean what a quality to go through life with, you know to keep on going with something. In a structured environment, if she can't do something she might have a little tantrum rather than persevere with it but that might be because there's other students around her, here she's on her own doing it, an individual task, I don't know whether you can compare it. She's not getting the attention here, so she is left to run everything, how many staff we have, a lot of it could just be, I mean you just don't know.

Description of sessions

ISC 1

Karen's first visit to the ISC took place in the second preliminary study (Cycle 2) with activities relating to Energy and Electricity.

Karen's attention is engaged from the start, she is looking at equipment on the table during the initial demonstration and when invited makes a prediction, correctly, about whether a particular material will conduct electricity ('*make the electricity box work*')

(1.00). All activities are her independent choice and, although she doesn't stay very long at each, she gives them her full attention when she is there. She spends a short time at the Water-Lift at the beginning of the session (9.30) and adjusts the tube of her own accord but then moves away without following this through (10.30). She shows that she knows (or recalls from the demonstration) how to make the lights light up in the ring circuits (17.30-17.50), connecting up the circuits with no hesitation, and briefly experiments with the series circuit. At the Heated House (23.50) Karen picks up a temperature probe and places it in the house while looking at the computer screen, thus demonstrating an understanding of cause and effect separated by physical space (the house and the computer) and one which requires her to make the link between the sensors in the house and the display on the screen.

By 31.10 Karen has returned to the Water-Lift and remains there until 34.30. In this short space of time she shows an awareness of a problem (water is not coming through) and attempts to solve it by turning the handle faster. She later works in collaboration with a helper to adjust the tube and free the bucket because the wheel is not turning. When the wheel begins to turn she gestures 'phew' to the helper, acknowledging that a shared problem has been solved. Once her objective has been attained she walks away. She has shown no frustration at the fact that the equipment was not working as she intended and has accepted non-verbal intervention by an adult although she had rejected any intervention from a fellow pupil.

After a break for lunch Karen is filmed at the Wind Generator; she demonstrates that she knows how to use the stream of air to make the sails turn and then experiments with directing the air at other things. At one point she turns the air back towards the sails and they turn much more quickly; Karen recognises this success and holds the tube in this position for twenty seconds. Again she rejects another pupil's attempts to join in, although she does include her in her experimentation in the sense that she points the air tube first in her own face then in the other girl's. Karen's attention is fully engaged throughout this five minute episode.

At the 'scientists' conference' following the session Karen is asked which way round you need to turn the handle of the Water-Lift, she demonstrates but turns the handle the wrong way. Another pupil demonstrates the right way and when the helper asks why it needs to go that way, Karen replies '*fill with water.*' Her teacher asks, '*What fills with water?*' and Karen says, '*Cups.*' She appears to have understood the process despite frequently turning the handle the wrong way.

Follow-up 1

The first follow-up session recorded for Karen also took place during the second preliminary study (Cycle 2), four weeks after her first visit to the ISC.

During the discussion at the start of the session Karen demonstrates with mime a clear recall of an activity in which the pupil holds a wire and stands on a foil covered plate to complete a circuit. Answering a verbal question about why she thinks this worked is more difficult, she replies, *'not sure (?) through stuff.'*

The follow-up activities give a better indication of her understanding. The activities that Karen uses consist of the water-wheel part of the Water-Lift, the Transitorised Light Box and separate wires, bulb and batteries to make a basic circuit. Karen is able to make both the water-wheel and the circuits work without hesitation. When she uses aluminium foil to complete the circuit of the Light Box and the light does not come on she clearly knows this is not right and asks another pupil to swap boxes. She is less keen to make a simple circuit at H1's suggestion but when asked again shows that she can do this easily. She has had some experience of circuits before the visit to the ISC but not of anything resembling the Light Box.

Karen's attention was engaged throughout the fifteen minute session to the extent that she was reluctant to finish when requested to do so.

School 1

The first school session recorded for Karen took place in the first year of the main data collection phase (Cycle 3). It was filmed in the laboratory of the mainstream secondary school where Karen's special school class was based. Bunsen burners were used to heat a variety of materials in order to find out whether they would melt. The students followed very precise instructions from a worksheet and from the teacher. Each group of two or three students was closely supervised by an adult.

The first seven minutes of the video-taped session are spent reading through and looking at illustrations on the worksheet. Karen is rolling a pencil and her attention appears to be on this, although she may be listening to what is said. She looks at the teacher when the latter invites the first pair of students to go and get their equipment and watches them as they move to do

so but then returns her attention to the pencil. When the teacher invites Karen's group to get their equipment, she stands immediately but is then told she can't start until her form is filled in. She does this, watching the others getting the equipment from time to time (7.25-8.06). Karen is off camera for three minutes then can be seen wearing safety goggles and actively participating in assembling equipment. Fourteen minutes into the lesson Karen's group clearly think they are ready to start but the teacher prompts them to look at their worksheets to check whether they have all they need. Karen adds to the equipment when prompted but as soon as the teacher's attention is elsewhere hers returns to her goggles or to other members of her group, looking at one of them through the goggles and rubbing noses with him at one point (18.30).

Twenty-one minutes into the lesson the teacher gives the other groups the go ahead to start under adult supervision but says that Karen's group won't be starting until they think about what they are going to do. Karen looks round at the other groups but makes no move to study the sheet until prompted again, then she and one of the other students in her group make a game of pulling the sheet away from each other. They gradually fetch the rest of the equipment but not without further reminders and exhortations to think. After twenty-four minutes the teacher tells Karen's group that it will be time to pack up in five minutes and they won't have started but a minute later she helps them to finish setting up and light the Bunsen burner. There is a further delay because the matches are used up; the mainstream science teacher who has been working in the background says, *'I hope you're not going to use my year's supply of matches'* and tells them to leave one burner alight and light the others from it with spills. Karen's teacher tells Karen's group to move aside so she can do this safely, Karen turns and makes a thumbs-up sign to the camera.

After around thirty minutes Karen's group's burner is alight and the students watch as the teacher adjusts the flame. The teacher reminds them of the purpose of the experiment and a student is invited to choose a material to test. The others are reminded again of the safety rules while he does so. When he returns with a piece of chocolate the teacher helps him to put it in place and then asks the students to predict what will happen. Karen predicts that it will melt. Nearly five minutes later the chocolate appears unchanged (it is being heated over water which has to get hot first) then it starts to melt. The teacher asks what is happening; one student says, *'it's going down'*, the teacher prompts *'it's me..'*, another student says *'metal'*. The teacher brings the worksheet and Karen reads *'melting'* from it. The teacher gives out the sheets for the students to put a tick against the picture of chocolate, Karen ticks the ice cube and is told (pleasantly) to cross this out. Soon after it is time to clear up; the teacher does most of this as the

equipment is still hot. Karen puts the goggles away. Back in the classroom, the teacher goes over the lesson; Karen contributes only once, saying that the chocolate melted.

Comments

In a lesson lasting approximately fifty minutes, Karen's attention appeared actively engaged on the intended task for only about ten minutes and much of this was spent simply watching the chocolate melt; more time was spent rolling a pencil or making faces at other students. It may be that there was less opportunity for active participation in this session than usual because of the risks attached to the use of Bunsen burners but the teacher made it clear that behaviour in the mainstream science laboratory was always carefully controlled. When this session was discussed during the semi-structured interview with Karen's teacher (using the video to stimulate recall), she said she thought that the worksheets could have been a distraction from the experiment but also thought that the students showed good concentration. She said that behaviour was generally calmer in the laboratory because the students were aware of the dangers. She suggested that Karen would probably find the concepts involved in the melting experiment quite difficult, but that these could be taught through 'pure reinforcement'.

ISC 2

Karen's second visit to the ISC took place in the first year of the main data collection phase (Cycle 3). It was her first experience of the activities relating to Forces and Movement.

Introduction

The first six and a half minutes of the session are taken up with the introduction. Karen is attentive from the start, constantly placing herself in front of other students as H1 demonstrates the equipment, responding to what is said as if it were addressed to her alone.

Activities

Karen is off-camera for more than half a minute at the end of the six minute introduction so it is not clear whether she has chosen the first activity of her own accord. H1 shows her how the pulleys work and Karen tries out what she has been shown. She is clearly interested but is not at this point working to her own agenda. After two minutes she is distracted by another activity and moves off camera but quickly returns and tries to solve the problem of one of the ropes coming off the pulley. She is assisted, silently, in this by H2 and accepts this help, holding one rope and waiting for the other to be ready. H2 demonstrates how the green rope tips the bucket and offers a ball. Karen places the ball in the bucket and pulls on the green rope, tipping it out, H2 reminds her that the green rope tips the bucket, Karen does not respond to this very brief verbal input. She continues to use the Pulleys for five minutes and for the last two appears to be trying different combinations in order to achieve her goal of getting the ball into the gutter.

At 14.10 Karen walks over to where an LSA is helping another student at the Wind Tunnel. Karen watches until the LSA says, *'Shall we show Karen? Look Karen'*. Karen walks away despite the LSA's attempts to call her back, she shows brief interest in the Detached Leg and pulls on the string when instructed to do so but then walks away again. She is off-camera for most of the next two minutes then when she is seen again she is at the Magnet but quickly gets up and moves very deliberately to the Wind Tunnel (17.40) which is now unoccupied. She works there with great concentration for six minutes, only very briefly distracted on two occasions by movement or noises around her. She does not appear to be discouraged by the fact that the task she has set herself (sellotaping card to a car) is physically difficult for her and does not become frustrated by repeated failure. She perseveres and adjusts both the card and the sellotape when the card lifts up in the wind on the first trial. When she returns to the tunnel with the car she seems to anticipate success, launching the car with arms outstretched, and giving a satisfied *'Yes!'* when it moves slowly down the ramp. After a further success, greeted by her with raised fists, she switches off and moves rapidly off camera (23.20). Apparently her goal has been achieved.

When Karen is on camera again three minutes later she is at the Motion Detector, trying unsuccessfully to reset it on her own. H1 shows her how and Karen moves watching the screen, clearly aware of the link between what she is doing and the graph on the screen. She tries to reset the Motion Detector on her own but is not successful; H1 encourages

her to try again guiding her step by step, then moves away and Karen continues to reset successfully on her own. She remains at the Motion Detector for a further three and a half minutes, changing the way she moves within the box, and the pace, running, walking and hopping, backwards and forwards, apparently exploring ways of making different patterns on the screen. During this exploration an LSA asks Karen what she is going to do, to which she replies, '*run*' and does so but stops when she gets near the screen and watches intently then exclaims, '*Yes!*' again with a gesture of triumph when the line reaches the end. (As it is a time/distance graph standing still causes the graph to continue but in a horizontal line, something that mainstream pupils found difficult to understand. Karen's response was not observed at the time so it was not possible to find out if she could repeat this effect deliberately but she was clearly interested). She resets the machine and begins to move slowly but then moves across the room and off-camera (31.30).

When Karen is seen again, five minutes later (36.50), she is kneeling beside the Electromagnet where another student has been working for some time. Karen is working alongside him but does not really appear to be co-operating. He gets up and walks away and Karen takes his place. She tries the available objects in the magnet in a fairly random way at first but appears surprised when one iron bar pulls another out of the solenoid but fails to pull a metal spoon out, and again when a piece of lead is not drawn in. She goes on to try a variety of objects in the magnet in a more systematic way looking closely at what is happening then appears to set herself the goal of pulling a metal spoon out of the magnet using other metal objects. She expresses clear satisfaction when this is achieved after several failed attempts. She returns to trying out different objects; at one point she picks up, then appears to reject, a plastic spoon, perhaps aware that this is not magnetic. After five minutes she is distracted by noises behind her and gets up and walks away (42.30).

She is briefly off-camera then is again at the Detached Leg; she appears to be attempting to attach a piece of string to it but her goal is unclear. When H1 offers her the force meter to measure the pull needed to straighten the leg, Karen accepts, saying '*oh yeah*', uses it briefly, but then walks away. Fifty-four minutes into the visit she has returned to the Pulleys and works briefly in collaboration with a fellow-student, who holds the bucket for her to roll the ball into. She says, '*watch*' as she rolls the ball and when it misses says, '*rubbish*', which makes him laugh and she does not appear truly frustrated.

'Conference'

When H1 asks the group as a whole what they liked doing Karen is again the first to respond and frequently answers questions addressed to others. She shows clear recall of what she did at each activity and what happened, supplementing speech with mime or demonstration, for example showing the zigzag pattern she had made on the Motion Detector screen with her hand. She also indicates which objects were pulled into the solenoid and which were not. There is no discussion of *why* things happened.

Comments

At no point when Karen was on-camera was her attention other than fully engaged for more than a few seconds. Her level of engagement was only reduced when she was very briefly distracted by movement or noise, when she was avoiding adult direction or instruction, or when she had finished what she wanted to do at one activity and was looking for another. She did not stay very long at each piece of equipment but was very involved while she was there in most cases and didn't appear to be 'flitting' from one thing to another. She was determined to be independent, avoiding the LSA's attempts to get her to join her and another student at the Wind Tunnel, returning there as soon as it was free. She accepted help when she needed it, appearing to respond better to non-verbal 'scaffolding' than to verbal input. She persevered at goals of her choice and did not appear to become frustrated by failure. She showed an ability to adapt what she was doing to achieve her self-selected goals.

Follow-up session 2

The second follow-up session recorded for Karen took place three weeks after her second visit to the ISC in the first year of the main data collection phase (Cycle 3). Karen was in the middle of an art lesson when I arrived and was very reluctant to leave this, so did not take part in the brief discussion at the beginning.

When Karen joins the group H1 asks her what she remembers from the visit to the ISC. Karen gives very little response to verbal questioning but as soon as she goes to the follow-up version of the Tilting Gutter she clearly knows what to do. She is able to make adjustments to get the ball into the bucket and shows pleasure each time she achieves this.

H1 brings her a wooden pole and pulleys that are very different to the much larger metal versions in the ISC. Karen confidently begins to thread the red rope onto the pulley while H1 holds the pole. She accepts some non-verbal or very brief verbal scaffolding but remains in charge making it clear what she wants H1 to do. H1 challenges her to get the ball from one bucket to another using the ropes and she plainly knows which rope to use to raise the bucket and which to tip it.

School 2

The second school session recorded for Karen took place in the second year of the main data collection phase (Cycle 4). The session was devoted to filling in a worksheet on 'time' for a module in an accredited scheme.

Karen is working in a small group with an LSA. She participates in the first part of the session, which involves going over the questions on the sheet, such as '*What day is PE?*', using the timetable to answer; Karen reads out questions when asked. After ten minutes she is told to write the days on the sheet (other students are cutting and sticking the words). The LSA continues to go through the questions and Karen answers even though these are addressed to another student. After twelve minutes the students are regrouped to begin the task.

After Karen has been allocated a seat she looks round, making no attempt to write. Fifteen minutes into the lesson she is asked if she remembers what to do with the worksheet and is reminded that she needs to put the date and her name on the back. She shifts her position but makes no move to write. One minute later she is prompted again with, '*No more help. Off you go. 'Cause when you assess it later you can say how much help you had. You can do most of it by yourself*'. Karen then picks up the scissors and makes to cut the sheet. She is reminded again that she has to write today and that the list of days is just to help. The task is repeated: '*Find your day and then write it here. What day do you swim? Then you write it here. Yeah?*'. After a further minute Karen thumps the table then taps her sheet with the pencil, looks at the sheet, then at her neighbour,

then puts her hand over her face; she does not appear to be writing. She rolls her pencil for several seconds then picks up crayons. Twenty minutes into the lesson Karen begins to write and does so intermittently for about two minutes, occasionally looking around or fiddling. She stops and looks behind her. The LSA notices this and says, '*Karen, how are you doing? Karen if you haven't finished you'll have to do it this afternoon with S (teacher)*'. Karen puts her head down on the table, the LSA moves round beside her and says again, '*you need to finish it. I know you like working quite slowly but you need to*'. Karen is shaking her head but does return to writing intermittently for a further ten minutes with increasingly long pauses in which she looks around, taps her pencil or puts her head down on the table.

Comments

Karen participated in the discussion (ten minutes), reading and responding to questions, but needed a great deal of prompting to complete the written task. It may be that she was receiving less support in this session than she was used to as this was an assessed task.

ISC 3

Karen's third visit to the ISC and second experience of activities relating to Forces and Motion took place in the second year of the main data collection phase (Cycle 4).

There is no introduction to the activities on this occasion, only a brief reminder from the teacher that this is 'choosing' but that students must remember to take turns and to share. Karen gets up almost immediately and goes to the Pulleys, the others don't move. H1 asks her if she remembers this activity, she says, 'yes' and pulls on the green rope, making the bucket tip. H2 reminds her that that rope makes the ball come out, she replaces the ball and uses the red rope to raise the bucket up. She then tries to tip the ball from the bucket into the gutter by holding the handle but can't really reach; she lowers the bucket halfway, takes the ball out and places it into the gutter by hand, solving the problem in her own way. She attempts to get the ball into the gutter using the red rope to raise the bucket and then freeing a hand to pull the green rope to tip it; she clearly knows how to do this but it is a tricky manoeuvre for one person, however

dextrous, and she returns to raising the bucket and then attempting to tip it by hand. When the ball doesn't come out she jiggles the bucket and, when it still doesn't, again places it in the gutter by hand so it rolls down and into the bucket on a spring at the other end. Karen then repeats the procedure; she appears to have achieved her aim but there is no gesture of triumph on this occasion.

Karen is off-camera for over a minute (4.50-6.15) apart from a brief glimpse of her at the Motion Detector. When she is seen again (6.35) she is standing at the Electromagnet; she tries a variety of objects in the magnet and again seems surprised by the lead, jiggling it about as if she expected to feel a pull but doesn't. Someone shouts from the Tilting Gutter, Karen runs off-camera in that direction (7.25). A fellow-student, Bill, has been unsuccessfully trying to get the ball to roll down the tilting gutter into the small blue bucket on the floor. Karen gestures to herself and then to Bill and moves beside him. Bill tries again, the ball falls short, Karen runs to retrieve it. The teacher reminds her about sharing but in fact Bill seems very happy to make way for her and applauds as she runs back with the ball. Karen takes Bill's place and rolls the ball, also missing. She ignores a helper's attempt to prompt her to move the bucket but when she has missed a second time she rolls the ball down the gutter to Bill who rolls it back by tilting the Gutter back towards her. They repeat this several times. After the ball has dropped again the helper tries again to prompt Karen to think about how to get it in the bucket, Karen ignores this but beckons to the helper to go somewhere else with her. They move off-camera (8.30).

Five seconds later Karen is at the Motion Detector. H1 sets it and moves away, Karen moves slowly backwards and forwards watching the screen, making an impatient gesture as the graph finishes. She presses some keys on the keyboard then turns and calls '*Can you help me?*' H1 points to the keys in turn for Karen to set the apparatus going again then moves away. When the computer needs re-setting again Karen appears to make two unsuccessful attempts and is then successful. She spends nearly two minutes trying out different ways of moving in front of the Motion Detector, varying her speed and watching the screen (9.20-11.00) then moves over to join another student, Jackie, at the Thump Wave announcing '*I'll have a go at that*' as she arrives. Jackie is gently hitting the drum but not looking at the effect she is producing. Karen hits harder, looking at the clown then takes Jackie's hand and hits the drum with it. Karen goes round and looks into the drum, which appears to be wrongly positioned so producing no effect, and shrugs. She hits the drum a few more times but without looking at the clown and when someone calls from the Wind Tunnel she goes over in that direction (11.40).

Karen is off-camera for nearly a minute (11.50-12.40) then can be seen working with enthusiasm at the Wind Tunnel. She takes a car out of the tunnel, places hers at the top of the ramp and as it runs down exclaims, 'Yes!'. She takes another car, which also runs down, says, 'Yes!' again and gestures to a fellow pupil to pass her a third car. When it too goes down she says, 'Yeah!' and jumps up and down. This episode lasts only thirty seconds (12.40-13.10) but Karen appears to be carrying on where she left off on the previous visit. She is again off-camera briefly and is then seen at the Detached Leg, putting string round it but not really looking at what she is doing. She shows only a vague interest in this activity for nearly two minutes, then gets up and walks away (15.15). She is next seen at the Pulleys (18.15) where she works with more sustained interest for nearly three minutes (18.15-20.55), again clearly aware of which rope performs which function – testing to make sure – and of what she wants to achieve. She makes adjustments to do this, showing no frustration at setbacks, such as the bucket dropping to the floor or the gutter coming off its support. She ignores verbal intervention from a helper.

At 20.55 she walks off-camera and is next seen using model fin-making equipment (plastic straws, scissors and sellotape). Her back is to the camera, she appears engaged in what she is doing but more distractible, turning frequently. At 23.45 Karen moves off camera again and at 24.35 comes over to the Thump Wave with Jackie. John (another student, not a participant in the study) is already there with H3. H3 directs John to stand in front of drum and Karen to hit it to see if John can feel it; Karen hits it several times, hitting really hard the last time. John moves away, H3 suggests Karen take his place, Karen runs in front of clown, her response to feeling the air is not visible. Karen moves on after less than a minute at this activity (25.10) to the Dominoes. H3 goes with her and asks what she is going to do; Karen's response is inaudible but after a short time she gestures to the box of loose dominoes, which H3 passes, and then Karen asks for help in setting them up. H3 works with her until 27.40. At 28.30 a fellow pupil comes over and offers help but this is rejected and the other girl moves away to the Thump Wave. Karen tries to put the fixed dominoes up but she is starting from the wrong end and they fall. She joins the other student at the Thump Wave (29.05). Here Karen directs operations, positioning the other girl and then herself in front of the clown so they feel the wind.

When next seen (30.40) Karen is at the Skeleton with H3, Karen is turning the pedals. She watches the effect then stands and says to H3 'You do it then', H3 kneels to do so, Karen watches briefly then moves over to the Detached Leg (31.05). She measures the leg and then appears to be trying to tie string to it. She again asks H3 for help, H3

moves across between Karen and the camera. Karen is briefly visible trying to tie the string to the hook then off camera until 35.20 when she is seen running across to the Tilting Gutter. She stays at the Tilting Gutter for approximately two and a half minutes, watching where the ball lands and adjusting the tilt of the gutter as the ball rolls down and encouraging Jackie to join in with her.

At 37.35 Karen moves on to the Pulleys. Again she clearly knows which rope to use and appears to have a particular goal but makes fewer adjustments to achieve it until a helper goes over and together they work the two ropes with Karen directing until the ball rolls down the gutter and into the bucket on a spring. Her aim apparently achieved (42.25), Karen moves on to the fish tank. She shows some interest in watching the fish through the lenses and when she is joined by another student pushes her gently to one side. However, she turns quite frequently, apparently distracted by the noise of the Wind Tunnel, and at 43.30 moves off-camera. She is off camera for over 8 minutes and at 52.20 is seen again at the Pulleys with a helper. Again Karen is in charge, making and directing adjustments. She continues there until 58.20 when she moves off-camera until the end of the session.

Comments

Karen's attention was again engaged throughout. She spent little time at each piece of equipment but appeared to know exactly what she wanted to do there. She seemed to remember the activities from seven months previously. There was some collaboration with fellow students, more than on her first visit. She appeared to like be in control, frequently ignoring suggestions from helpers but asking for help when she needed it.

Follow-up 3

The third follow-up session recorded for Karen took place two weeks after her third visit to the ISC during the second year of the main data collection phase (Cycle 4).

During the very brief discussion Karen is looking at the equipment that has been brought in. She joins in only once; when another student mentions the Thump Wave drum Karen mimes hitting it.

Karen spends a minute at the start of the activity session looking at the hairdryer, which has been provided in place of the Wind Tunnel to use with the model cars, then walks off camera. After approximately three minutes she moves to the Electromagnet where John is already seated and begins to adjust the dials and try the iron bars in it. The degree of collaboration is unclear as they have their backs to the camera but she seems to be reaching across him and when he gets up takes his place with a pleased expression. She tries various objects but is quickly distracted by something that is happening behind her and jumps up and runs to join John with the cars and hair dryer. John returns to the magnet and Karen switches on the hair dryer with no hesitation and blows a car straight off the table. She begins to cut card and stick it to a car as she had done at the ISC – her design is not clearly visible – then uses the dryer on it. A little later she is using the dryer alternately on the car and on her own face. She continues to use the dryer for five minutes, varying what she is doing.

At 10.15 Karen is sitting by the Electromagnet working intently with the small circuit provided alongside it and then with some small magnetic frogs. At 12.15 she begins to pick up the pulley rope and bucket, then the bar and starts to adjust the pulleys on the bar. H1 holds the bar and invites Karen to tell her what to do. Karen does so, participating herself until the ropes are set up on the pulleys. Karen uses the red rope to pull the bucket up; H1 asks '*What about the green rope?*'. Karen makes to take this and the red one slips, she appears to try to secure the red rope to solve this problem but is then hidden by another student (18.15). At 21.35 she has returned to the Electromagnet, again adjusting the transformer dials, trying various objects in the magnet, feeling and looking inside.

The session ends at 24.35.

Comments (all sessions)

In the science laboratory in school Karen focused on the task set (following and filling in the work sheet) only for very short periods, mostly when expressly told to do so. She rarely worked on her own initiative but there was little scope for this (safety concerns may be a factor in the very directive approach used). The teacher

said she thought the students' concentration was good in this session but in fact the video showed that Karen was frequently off-task. In the second school session Karen participated in the question and answer session but avoided the written task until told she would have to stay in at lunchtime to complete it.

At the ISC Karen was quick to understand the possibilities of the equipment including cause and effect at a distance (for example the link between her movement in the Motion Detector box and the graph on the screen) and showed interest in exploring them. She also showed an ability to work with great concentration and did not become discouraged by failure to achieve a self-imposed goal when she had chosen the activity. She tended to avoid adult direction but asked for help and appeared to enjoy collaboration from her second visit as long as she remained in control.

4.2.4 Bill

Pen-portrait

Bill was sixteen at the time of his first visit to the ISC. He was in the same class as Karen and was described in his school report as ‘associating’ with mainstream students for registration, break times and some PE lessons. Bill’s ‘statement of special educational needs’ noted that he had Down syndrome ‘with attendant intellectual delay’ and delay in speech and language, needing a lot of Makaton signing. He was said to be able to use five to six word sentences in an informal setting, two to three in a formal setting. He had a hearing aid in his left ear and no hearing in his right ear; his teacher remarked that he had recently been given a radio system to help his hearing and that this had made a considerable difference. The ‘statement’ also noted a determination to do things for himself that could ‘get in the way of teaching him’ and that he could get frustrated, with occasional rigid non-cooperation. His school report, written at about the time of his first visit to the science centre noted that he would answer a question directed to him, but did so less when the question was directed to the whole group. He was said to listen attentively and to be becoming more tolerant of others interrupting a discussion.

Bill’s school report further noted that he was able to read from a reading scheme supported by visual symbols and was beginning to use phonics. In maths he was reported to need a little help to count to twenty and to be able to read and write numbers to ten and in science to be able, with a little help, to decide whether a strong or weak force was needed to move a mass, classify living things into groups and identify their habitats and with help to be able to sort gases, solids and liquids. The objective set for him was to be able to make predictions and say why things happened.

The report further noted that Bill was able to use the canteen independently and to buy things in a supermarket (supervised outings). He had done work experience in a supermarket (collecting items and stacking shelves). Contact with other people was said to need to be monitored as he had a tendency to hit out. He was said to be very hard to motivate (informal communication).

Bill's teacher said that he found concepts very difficult to understand because of his language difficulties and particularly had difficulty with questions such as 'when?', 'why?', 'how?' She did not think he would have understood the concepts behind the session on melting observed in the science laboratory. She suggested that Bill needed direction: *'because of his language and his comprehension he would find it difficult to understand what's expected of him even if it is it might take a while for him to understand that you can be independent and do things on your own, he usually goes for a reasonable amount of direction'*.

She remarked that the other students were afraid of Bill and was surprised by the degree of collaboration between Bill and a fellow-student (John) on Bill's second visit to the ISC, putting it down to John being submissive, although this was not how it appeared from the video as they appeared to be collaborating on more or less equal terms. She had said she did not think he would be likely to experiment in the ISC but commented on the fact that Bill and John appeared interested in cause and effect and experimentation as well as on the pleasure they derived from their game with the magnet:

I think if you had a different variety of things Bill would try them but whether he would understand why, I don't think he would think further than it would just be different ... but they're really enjoying the basic cause and effect there, they've got two different things there, between them selves they've set up a cause and effect situation and they've got the actual experiment itself, haven't they?

Description of sessions

Bill was absent for a number of sessions, mainly because of work experience.

ISC 1

Bill's first visit to the ISC took place during the second of the preliminary studies (Cycle'2) with activities relating to Energy and Electricity. He was absent for the preliminary study follow-up session.

Introduction (0-8.55)

Bill watches as H1 introduces the activities, not actively participating but appearing interested, moving round so he can see.

Activities

H1 says she will help the students if they want help but invites them to see what they can find out. Bill is seen briefly looking at, but not touching, the computer linked to the Heated House (9.35 – 10.50) then is at the Circuits. He looks intently at the ring circuit, plugging in one lead then another, nothing happens (he is perhaps plugging the leads into the wrong sockets), he looks around (12.05). H2 comes over to show Bill what to do, he walks away and off-camera. (12.15).

When next seen (15.05) Bill is kneeling by the Water-Lift, turning the handle and intently watching the water coming out of the cups. A fellow-student tries to take the handle, Bill ignores this and continues to turn, then changes direction back and forth, still watching. An LSA comes over (19.0), Bill continues to turn the handle at first but then sits back on his heels and smiles at her and shakes his hands (apparently with pleasure). Other students come over (19.30), Bill quickly starts to turn the handle again before they can take it, watching the cups and the wheel then reversing the direction in which he is turning. After a brief time off-camera, another student is turning the handle, Bill gets up and starts to walk away but then stops and watches the water going into the upper reservoir before leaving.

He shows brief interest in the Heated House and the Pendulums then returns to the Water-Lift (22.10). Two students are already there; Bill leans over and takes the handle from one of them but otherwise ignores them. After thirty seconds off-camera he is still turning the handle but then stands and the other two take over again (he may have been told to let them

have a turn). He flaps his arms and turns away then notices the camera, puts his face very close, spreads his arms then walks away (23.35). Bill is next seen at the Circuits, watching the spinner and smiling (24.0). He unplugs and stops it, plugs it in again and watches it turn, bending right over it, clapping and jiggling, clearly pleased. He unplugs it again, looks closely at other parts of the circuit then moves to the other circuit table (24.30) and looks closely at this. He is off-camera for nearly two minutes and when seen again (26.30) is back at the Water-Lift where a fellow student is turning the handle. Bill bends down, hands on knees to watch where the water is coming out of the cups.

Bill is briefly off-camera and when seen again (27.35) is going over to the Wind Generator, another student (John) who is using it immediately moves away. Bill picks up a piece of card from the floor and holds it in the air stream. It is blown out of his hands, he picks it up and holds it in the air again, varying the position, apparently exploring the difference this makes, he releases it and it is blown away again. Bill smiles and moves away (28.10). He moves back to the Water-Lift (28.25); the student who was at the Wind Generator is turning the handle but again moves away when Bill arrives, another student takes over and Bill watches. He is told by the teacher that a third student is waiting for a turn, and that he needs to check if someone else is waiting. He moves round to watch the water.

After nearly 2 minutes off-camera Bill is at the Heated House (31.05) looking at the computer then at the house. An LSA comes over (31.20) and turns the computer so it is easier for Bill to see the screen (which displays the temperature on large thermometers) while standing at the house. She helps him place the sensor in the house, he holds it in but doesn't appear to be looking at the screen, perhaps not understanding the connection between the sensor and the screen. Bill shows brief interest in the Water-Lift (32.0) and the Pendulum ball (33.50) before again returning to the Water-Lift, which is temporarily unoccupied, but as he moves towards it another student reaches it first and begins to turn the handle. Bill watches, flapping his hands and bouncing gently up and down. He touches the top reservoir then moves round in front of the other student (35.10), takes the handle, squats down and begins to turn, watching.

From 35.15 he is off-camera., then at 36.20 he goes over to the circuit table where another student (Jackie) is working and picks up the leads from a light and begins to plug them in, watching the spinner rather than the bulb. He leans across in front of Jackie, ignoring her, to plug one lead from the bulb in by the spinner, the other by the bulb; the light comes on, Bill claps. He takes one lead from the spinner (the other is already plugged in), plugs it into the other socket by the bulb, the spinner turns. Bill smiles at Jackie, claps then jiggles as he watches the spinner turn. He unplugs the spinner, plugs it in again, several times, then

leaves it on, jiggling his whole body as he watches it. He has successfully used the equipment in his own way, rather than as it was intended (i.e. plugging both leads in next to the object they are attached to: this only works if the leads are plugged in the right way round beside the other object although this may have been luck). His pleasure when it works is clear. He moves away (37.45) but soon returns (38.40), unplugs the bulb, plugs it in again, leans across Jackie, ignoring her, unplugs the spinner, plugs it in again, raises one arm, leans over and jiggles in time with the spinner, unplugs it, raises both arms in a gesture of triumph and walks away. (39.05)

Another student (John) is heading towards the Water-Lift, Bill moves in front of him and takes the handle, John shies away. Bill turns the handle, bending over, watching the water coming out of the cups. At 41.35 he stands and walks off-camera and at 41.45 he is again at the circuits, bending over the turning spinner. He unplugs one lead, plugs it in again, watches, jiggling his legs. He looks carefully at the sockets, unplugs the spinner, plugs in a bulb, looks closely again and plugs in a second light. He is certainly making adaptations and seems to be investigating different possibilities. He is briefly off-camera (42.20-42.40) then seen again watching the spinner and jiggling. He looks at the Circuits, takes a lead across the table to a different socket, plugs it in and as he does so he must knock the lead for the other bulb, which goes out. Bill looks at this and plugs it in again. He lifts the other bulb, plugs in one lead, tries to take the second lead across the table, the first one comes out again. Bill tries another bulb and socket; again he appears to be exploring as well as problem-solving. At 43.45 H2 comes over and starts to demonstrate plugging leads in, Bill looks briefly at what she is doing then moves to the other circuit table where John is working. He leans across John and begins to make connections there too but moves away again after ten seconds.

Bill is only seen again briefly at the end of the session going to the circuit table where another student, Sally, has got the spinner working. Bill unplugs a light, plugs it in again and unplugs the spinner, Sally pulls it towards her, Bill looks at her, she plugs it in again, Bill smiles at her then unplugs it, Sally pulls on the lead. H3 intervenes before the equipment can be damaged.

'Conference'

Bill does not contribute to the discussion until specifically asked which activity he liked (5.0) then points (apparently at the Wind Generator). When asked why, he says, '*Head*' and touches his head and laughs. When asked what else he liked he says, '*Don't know*'. His teacher says, '*You do know. What else did you do here?*' Bill looks down, playing with his hair, says '*Umm*' then '*Nothing*'. Later H1 asks, '*Anybody else have anything they'd like to*

tell us about?' Bill points at himself but when asked what he wants to say says nothing and may have misunderstood the question.

Comments

Bill did not stay very long at a time at most of the activities but always seemed involved and showed particular interest in the Water-Lift and the Circuits. At the circuits he showed an understanding of cause and effect, an ability to problem solve when a lead was knocked out of its socket, and the beginnings of innovation and exploration: trying out different leads in different sockets. He did not appear to understand the more abstract link between cause and effect at the Heated House, between the temperature sensors in the house and the graphics on the computer screen. He mostly ignored fellow-students, leaning across them or taking something out of their hands, they, mostly, did not resist and tended to move away. Bill for his part tended to move away from attempts by staff to explain or show things to him.

School 1

The first school session for Bill, as for Karen, was the science lesson on melting which took place in the mainstream secondary school science laboratory in the first year of the main data collection phase (Cycle 3). He was absent for the second school session.

During the brief sequence recorded in the students' usual classroom before going to the laboratory when the teacher is talking to the students about safety and how to behave in the laboratory, Bill looks at her while she speaks but doesn't respond. When he is seen next (1.20 – 1.30 and 3.0 -3.30) he is sitting in the laboratory sharing a table with another student and an LSA; the teacher is explaining what they are going to do, introducing the different materials they are going to test. Again Bill looks at her but doesn't respond in any way, not even turning his head to follow her when she goes to get ice. At 3.35 the LSA points at Bill's sheet, he looks down and marks it with his pencil, then looks back at the teacher with more interest for a few seconds. He continues to look at the person speaking

while the teacher asks students to read the steps they are to carry out, but still shows little obvious interest.

From 8.05 to 8.40 Bill sits facing the front as others get their equipment, apparently waiting to be told what to do. The LSA who was at his table is occupied elsewhere. He is then off-camera for three minutes and when seen again is walking back towards the bench with a piece of equipment; it is unclear whether he has been told to do this. When he is seated again, he looks at his sheet and then across the room at what others are doing (12.10). He continues to look down or across the room until 12.50 when he puts on his goggles unprompted and looks around through them at what is going on. At 13.30 Bill beckons the teacher as she walks past and she says '*Well done, Bill, you're looking good*' but doesn't stop. He continues to sit watching. At 14.05 the teacher takes him some equipment and says something inaudible. Bill looks at what she is doing but makes no other response and continues to sit and watch. At 15.05 the LSA comes over, Bill turns to talk to her, points at his goggles, she walks away again. Bill puts his head down, hands on his head briefly (15.10) then adjusts his goggles and looks around again. At 15.20 the LSA goes over and speaks to him, he responds and flaps his arms briefly then looks round the room, the LSA moves away. At 16.15 the LSA returns with equipment, Bill watches but doesn't move and when she moves away again Bill looks across the room. At 16.55 the LSA returns and sits by Bill, he looks down. He is off-camera briefly and when seen again (17.25) is still sitting unmoving at the table. At 17.35 the teacher comes and talks to the LSA about the experiment, Bill doesn't react and from 18.05 to 19.00 sits looking around, tapping, then adjusting his goggles, yawning and stretching. At 20.55 the teacher gives two of the three groups (including Bill's) permission to start, Bill does nothing. Nearly a minute later the LSA asks '*What do we need to do Bill?*' Bill doesn't respond but she then gets him to show her on the worksheet what they need to do. From 22.0 to 24.45 he is sitting looking down then around, stretching, waiting while the LSA and the teacher sort out a problem with the gas. At 24.45 the LSA asks Bill if he is going to light the Bunsen burner, she holds his hand with the lighted splint and helps him light it. This done, Bill sits back, the LSA points at the worksheet, Bill looks. The teacher comes over (25.35), Bill watches what she is doing for 30 seconds then is off-camera for over a minute and when seen again (27.25) is adjusting his goggles and rubbing his face. He watches as the LSA puts ice in the pot over the burner but then goes back to looking round the room. The LSA asks him what is happening (28.45), he looks for nearly a minute then around the room again. At 30.45 the LSA asks Bill if the ice is melting, repeating the question with signs. Bill says, '*no*' and is told to keep watching. At 31.55 she asks what is coming off the ice, Bill looks but doesn't respond, then looks around again. At 32.20 the LSA says and signs, '*Oh, Bill, look what's happening!*'. Bill looks and says '*Cor*', the first real animation he has shown. For the rest

of the session Bill looks at the equipment or the worksheet when told to do so but doesn't again show very obvious interest. When asked if the metal is melting he says 'No'. From 43.30 to the end of the session in the lab at 45.30 Bill very slowly helps with the clearing up.

Back in the classroom the following exchange takes place:

Teacher: *What happened to the ice, Bill? Did it stay the same or did it melt?*

Bill: No response. Teacher: *What did we do?* Bill: *Burn.* Teacher: *Did it stay the same or did it go down?* Bill: *Open your eyes Bill. We had an ice cube and it was hard (sign) and we lit the Bunsen burner and what happened to it?* Bill: *Hard.* Teacher: *It was hard, but what happened when we lit the Bunsen burner, it m...* Bill: *Flat.* Teacher: *Well done, Bill, it melted and went flat.*

Comments

Bill sat quietly throughout and looked at the speaker, even when the whole group was being addressed, and at the experiment or the worksheet when asked, but only once showed obvious interest and real animation. His understanding of the concepts involved was not clear either from his actions or his brief contribution to the discussion afterwards. In the laboratory he only participated actively in lighting the Bunsen burner (with the LSA) and in clearing up the equipment.

ISC 2

Bill's second visit to the ISC and first experience of activities relating to Forces and Movement took place during the first year of the main data collection phase (Cycle 3).

There is no real introduction as most students have visited before. The teacher tells them, '*It's choosing*' and reminds them to take turns and share. Bill points to the Tilting Gutter, the teachers repeats that the students don't have to ask and says '*Off you go then Bill.*' Bill positions himself by the Tilting Gutter and begins to roll the ball down almost immediately, watching intently and smiling. Another student, Martin, who is in a wheel chair, joins him, holding a ball, Bill adjusts the gutter to make it easier for Martin to place the ball on it then tilts the gutter to roll the ball down; it hits the edge of the bucket (2.0). Bill moves the bucket much further away then rolls his own ball which falls well short. Martin holds a ball out again, Bill tilts the gutter towards himself in anticipation so that when Martin places the

ball on it it rolls down towards him and then tilts the gutter back as it reaches him, showing a capacity to anticipate and adapt as well as collaborate. Bill continues to roll the ball which continues to fall short. Martin moves away after approximately one minute and Bill continues on his own, moving the bucket further and further away although the ball is falling short. At 5.20 Karen comes over gesturing to herself and to the ball, Bill nods. The teacher warns her to share but the collaboration appears to be welcomed by Bill. He rolls the ball, she retrieves it and runs back with it, Bill applauds and makes way for her to have a turn. They then tip the ball to and fro between them on the gutter, making an innovative use of it, until the gutter comes off its stand. Karen goes to retrieve the ball, Bill speaks to a helper, pointing to the gutter. The helper asks *'Are you going to get it in the bucket?'* and helps Bill adjust the gutter. Karen beckons the helper to follow her off-camera and Bill's teacher comes over and, with a mixture of speech and signing, tries to get him first to tell her what she needs to do and then to adjust the bucket himself. He does eventually move the bucket much nearer but still doesn't seem to respond to where the ball falls. When the teacher has gone Bill gestures to a helper to retrieve the ball for him (14.0). She too tries to get him to think about the position of the bucket, using mainly gesture, with little success, then another helper asks him if he is going to move the bucket (17.15) and when he says, 'yes,' asks which way; Bill doesn't respond. After 19 minutes at the Tilting Gutter Bill moves on to the Pulleys.

At the Pulleys Bill again appears to know exactly what he wants to do. He attempts to rethread one of the ropes and accepts help doing this. He spends a further ten minutes at this activity, raising the bucket and tipping the ball from it into the gutter, showing no frustration when this doesn't work, making minor adjustments so that it does, such as jiggling the bucket with his hand. He shows no frustration either when the ball misses the bucket at the other end of the gutter but on the other hand shows no particular satisfaction when it goes in (25.0) perhaps because this was not a particular aim, or perhaps because he has no audience at this point. When it happens again (28.0) and a helper is watching he smiles and changes activity as if a goal had been achieved.

Bill returns briefly to the Tilting Gutter which another student (Jackie) is using. He rolls the ball that has been placed for her down the gutter and is asked to let her have a go. The ball falls short, he moves the bucket slightly nearer, rolls the ball twice more then moves on to the Motion Detector (29.05) where he moves backwards and forwards, watching the screen, while an LSA helps to reset. After less than a minute, the LSA gestures vertical zig-zags to Bill (it is not clear whether this is a suggestion of what he might do or comment on the pattern on the screen). After this Bill varies his movements more deliberately, bouncing or hopping, varying pace, making whooping sounds. He looks at the screen when he

reaches it, mimes exhaustion and moves away (31.00). At 31.25 he is at the Thump Wave Clown; a helper asks if he remembers it, Bill smiles and hits the drum, watching the effect on the clown. The helper asks what happened, Bill smiles again but doesn't reply. He hits the drum a few more times then walks away (32.0). He moves to the Dominoes, puts all the fixed dominoes upright then looks around apparently for an audience as a helper says, 'go on then' and Bill hits the first domino: they all fall. The helper and an LSA point out the loose dominoes but Bill ignores this; he puts the fixed dominoes up again and knocks them down several more times then moves away (34.05).

At 34.25 Bill is kneeling in front of the Wind Tunnel letting a car go into the wind, watching as it goes down the ramp. A helper offers a higher car, Bill takes it after a pause and lets it go, varying the angle, although it is not clear whether or not this is deliberate. He peers into the tunnel so the air is on his face, then looks up grimacing. A helper squats beside him, he grins and puts his head down again so the wind is on his hair. The helper offers card and sellotape (35.45) and Bill sticks the tape on the card; the helper offers a second piece, gesturing to the car but Bill ignores this and holds the piece of card in the wind. The card blows onto him, he turns to the helper and smiles. He continues to hold the card in the wind then release it until 38.05 trying out different ways of doing this, holding it against the ramp or out in the wind, shouting with surprise and then laughter when it blows over his head, holding his hand so the wind presses the card against it, holding the card at different angles, playfully exploring. At 38.50 he switches off the wind and walks away.

From 42.35 to 64.50 (over twenty minutes) Bill is at the Electromagnet with a fellow-student (John). They jointly develop a game – Bill slightly dominant but only slightly – pulling metal objects back and forth between them through the magnet (each using an iron bar at their end to pull something that is inside), both laughing. There is a rare instance of imaginary play when Bill mimes sword-fighting with an iron bar. The game continues until 52.45 when an LSA suggests trying other objects and H1 offers a plastic spoon to try. The students accept the suggestions but are less inventive when following them and soon return to their game. At 57.40 an LSA asks if they are alright, they look briefly at her and return to the game. At 57.55 their teacher asks if they want to go to the toilet, they give her their attention for five seconds then return once more to their game. From 59.50 to 60.05 they are distracted when Bill picks up some string and drapes it round John's neck but they soon return to the magnet. At 60.05 an LSA comes over and asks, '*how are you doing lads, does it stick together?*' They continue their activity without responding. At 60.15 the teacher tells Bill to share although he has been doing so all this time. An LSA comments on what they are doing, Bill reaches for a spoon which John is holding and is told again to share. The LSA tells John how to get the spoon out of the magnet, Bill pulls it from his side and

gets it, laughs up at the LSA, saying '*Yeah I got it!*'. At 62.50 the LSA asks if they are ready for lunch, Bill gives a slight shake of the head. They continue, John pulls the spoon out, Bill makes a disapproving noise but there is no real friction between them. At 64.50 H1 asks them to come and sit down because it is the end of the session, they stop without protest, having collaborated with clear enjoyment for over twenty minutes.

Comments

Bill was much more collaborative on this occasion, both with fellow-students and with staff but particularly in his game with John. Staff intervention during the game made very little difference except at the end to make them more competitive.

Follow-up 1

This was the first follow-up session for Bill as he had missed the previous one. It took place two weeks after his second visit to the ISC during the first year of the main data collection phase (Cycle 3).

Bill comes into the room as H1 is setting up the activities, he is on crutches, having hurt his leg. H1 asks if he remembers the Tilting Gutter, he says 'yes' and watches as she adjusts it. The LSA brings a wheelchair for him and takes him to the Gutter. Bill looks at it and smiles but makes no move to do anything. H1 comes over and picks up the ball for him, he says 'yes' and takes the ball (2.00), rolling it down the Gutter, it bounces on the floor then into the bucket. H1 exclaims 'yes!', and Bill grins. They work in collaboration, H1 retrieving the ball and moving the bucket to Bill's directions. When H1 moves away fellow-students (Lucy and Sally) take her place for the rest of the time that Bill is on camera (five minutes).

Comments (all sessions)

Bill changed considerably over the period of the research. From the start he engaged with activities at the ISC but in the first (preliminary study) year tended to ignore fellow-students and walk away from attempts by staff to help him. By the time of his second visit he clearly enjoyed collaboration, particularly with John, although the teacher when looking at this on the video said it was still unusual.

4.2.5 Michael

Pen-portrait

Michael was nearly nine at the time of his first visit to the ISC. His 'statement of special educational needs' noted that he was delightful, happy and well-balanced and that he had a good visual memory, was interested in books and enjoyed music. It also noted that he had Down syndrome and that his emotional development was delayed in line with his general developmental delay and that his reactions were those of a younger child. It stated that he 'generally obeyed instructions' but would 'switch off' or use avoidance tactics if tired or unwell or if he didn't want to do something and could become 'irritated'. He was said to prefer to 'do his own thing', preferably to sit or lie and 'twiddle' objects with his hands and the statement noted that he 'needs to be discouraged from doing this as it interferes with his learning', also that he 'needs basic play skills encouraged. He interacts with other children but will not generally take the initiative'. He was also said to have a short concentration span but might 'be capable of more than he chooses to achieve.'

Michael's most recent school report noted that his drawings of people consisted only of a face and that he didn't give them limbs without prompting. For English (speaking and listening) the report noted that Michael would sometimes suggest what to do next in a practical activity, could work in a small group at an appropriate comprehension level but needed prompting to participate fully as a listener in a group. A speech and language therapy report stated that he could understand two information-carrying words consistently, three if he really concentrated, but otherwise tended to pick the last object/request. It was noted that he often still used single words but tried to use phrases or short sentences. He was said not to use Makaton signs

effectively in expression but that these aided his comprehension. His school report said that he might seem not to be listening then surprise with an answer. In reading the report noted he could match words to words, was working on whole word and phonetic approaches and could recognise peer names, mummy and daddy. In maths he could count to ten with one to one correspondence, identify the symbols 1 to 5 out of order and sort objects into big and small if given only two objects. In science he could point to and name most external parts of the body, name a variety of animals and knew where some lived. He understood that things can be moved by pushing and pulling. He was 'integrated' into a mainstream class for half an hour of PE with a lot of support.

Interview with Michael's teacher

Michael's teacher felt he was not very motivated but that he sometimes surprised staff:

He will much prefer something practical to keep his attention ... he's not motivated very easily really unless it's to do with ducks or animals or Disney characters. He's poorly motivated and would rather sit and do nothing basically or twiddle with something. Twiddling and flapping, he's doing an awful lot of which we're discouraging it's such a big distraction for him ... but he can sit and concentrate reasonably well and there are times when you don't think he's listening and suddenly he'll utter something and you have to make sure that it's actually Michael that said it, so he can be quite deceiving at times but he's quite good if he gets something in his head that he wants to get across to you he will make sure he gets it across, he doesn't just give up.

She did not think he would be likely to do things on his own initiative:

Workwise, Michael would have to have somebody with him .. or at least be working in a small group... with an adult. And playwise Michael doesn't play unless ...he would sit and twiddle. He doesn't play with, I say that, he doesn't play with toys, in a group situation, or if we do role play, drama stuff, he loves it. So role-play he will do but actually playing with toys, he's got no interest at all. But he loves the water, water-play...

When watching the video of Michael in school she said that his behaviour was 'fairly typical' but that he probably 'participated more than he normally would.'

Of Michael at the ISC she said:

I mean Michael loved doing ... I say he'll sit and twiddle all day but, or if an adult would boisterously play with him all afternoon, he's happy on swings and roundabouts, that sort of thing, he does love, no it was lovely to see him actually ... when we do some sensory work, we've been doing the sort of sensory side he loves it ... But no, he's been and got a, whereas had you said to me he'll go and get a car and put it down there, I'd have said no he won't.

Description of sessions

School 1

The first school session recorded for Michael took place during the first year of the main data collection phase (Cycle 3).

The first twelve minutes of the session consist of discussion of what parents have put in the children's diaries about the weekend. Michael is distracted when other children's news is being discussed, enthusiastic when it is his own news (5.40-7.10). From 12.15 to 22.30 the children are drawing pictures and copying writing (or going over writing) relating to their news. Michael is mainly distracted, looking around, unless being told what to do. He very briefly works independently (18.10-18.50).

From 24.40 to 40.50 the children are sitting in a circle while the term's topic of toys and play is discussed. They are shown actual toys and called on in turn to say whether a toy is pushed or pulled and demonstrate. This is followed by a discussion of different types of weather, games that can be played in the snow and a story about playing in the snow. Michael sometimes looks at the speaker but is frequently distracted, looking around. When called on to demonstrate a toy (30.40), he does what he is told but no more, and confuses 'push' and 'pull'. He doesn't participate again until told to take his chair back to the table at the end of the session (42.25).

ISC 1

Michael's first visit to the ISC took place during the first year of the main data collection phase (Cycle 3).

Michael watches during the demonstration (0-3.45). From 8.10 to 8.40 he is at the Pulleys raising the bucket then letting it fall until another child (much more articulate, apparently more able) takes over and Michael moves away. He spends a lot of time between 14.25 and 18.50 twirling string and balloons, his thumb in his mouth but at 18.50 he is discouraged from doing this by his teacher who moves the box with these things in and takes Michael over to the Electromagnet where he appears intent for a short while (back view only) but then returns to twirling another piece of string (23.40). When next seen (27.10) he is playing with the Pulley rope which has become detached. An LSA re-attaches it and Michael takes the ropes after she has moved away and appears to be trying to sort them out. H1 goes over to help him (27.45) then at 28.25 moves away and Michael raises the bucket, watching as he does so. H1 returns and offers him a ball to put in the bucket; he raises it with the pulley, adjusting what he is doing so it doesn't fall out. At 30.30 he moves to a table, puts his head on it briefly, thumb in mouth, but then moves on to the Skeleton where he shakes its arm, looking up at it, then ducks under the arm and appears to be trying to climb onto the bicycle with the skeleton until called away by an LSA.

At 34.35 he is at the Wind Tunnel; he puts his face in the wind, jumps back squeaking with pleasure, flaps his hands, goes back towards the tunnel, turns so the wind is on his back, turns again so his face is in the wind, moves away slightly, then back, and reaches in for a car. He places the car on the ramp, it runs down and Michael reaches into the tunnel at the same time as another pupil (Freddie). There is no real interaction, positive or negative, between them. They pull out a foam ball, Michael throws it, missing the tunnel, and jumps up and down flapping his arms. He approaches again, his back to tunnel, carefully lowers his bottom to the ramp then jumps away again squeaking. He jumps up and down, turns back with a big grin, puts his face in the wind, then turns round and says something to someone behind him, pointing at the tunnel. He leans right down, his face in the wind for several seconds, stands, holds the ramp and leans with his face into the wind then stands back, with his hands to his stomach where the wind is hitting it. He goes forward again, stands holding the ramp, the wind in his face once more then leans down putting his face further into the wind. He reaches over to the table, takes a car, runs it down the ramp, turns sideways to retrieve it, pulls it to the top of the ramp, lets go, retrieves it again, half throws the car in from beyond the top of the ramp, then retrieves it once more. He rolls the car down twice more then the wind is switched off (it is not clear by whom). Michael takes the car out and the wind is switched on again; he rolls the car down the ramp. Freddie comes over, reaches in to retrieve the car, Michael takes another from the table and Freddie takes that one too. Michael doesn't protest but reaches over to the box and picks out a piece of card and places it in the Wind Tunnel; it flies out again, he picks it

up, smiles at the camera and throws the card into the wind again, it flies back. This is repeated several times then Michael retrieves the card, throws it harder and it is blown back further; he runs after it, laughing, and picks it up, grinning round at watching adults, and this time holds the card on the Wind Tunnel ramp before letting go. The card blows back again, Michael laughs, repeats what he has just done, laughs, looks round, apparently at the adults again, holds the card on ramp again and this time it blows right up in air, Michael laughs harder. He crawls under the tunnel to retrieve the card, and places it on the ramp again holding it longer on the ramp this time. When he lets go the card stays on the ramp an instant and is then blown back straight at Michael who catches it and smiles. Michael goes back to the tunnel and is holding the card out towards the wind when Freddie comes over with a car roof, Michael snatches the card back and Freddie holds the roof in the wind. Michael does not appear interested in what Freddie is doing except at one moment when they both peer into the tunnel. A teacher asks Michael for the card (38.35), says, '*ready?*' and when Michael, puts the card right into the tunnel and stands back, Michael jumps up and down in anticipation. She repeats this and the second time the card flies out onto Michael who laughs and retrieves it. When the teacher leaves again after about a minute Michael continues to explore the Wind Tunnel on his own. At one point he calls '*Watch!*' and an adult replies, '*Yes, I'm watching, go on then.*' At 39.40 an LSA brings another pupil over, she puts out her hand for the piece of card that Michael is using, he moves back with the card and the LSA moves up to the tunnel with the other boy. Michael is off-camera briefly then is seen sitting on the floor with the card which he is flapping, looking down at it.

He shows only half-hearted interest in other activities until 51.45 when he return to the Wind Tunnel. Again he tries out different combinations, placing a piece of card on the ramp, on his head and then right down inside the tunnel. When he has retrieved it he again places it on the ramp, holding it down with both hands, when he lets go it flies onto his stomach and stays there. He shrieks with laughter. He retrieves the card once it has blown away, holds it right inside the tunnel with both hands and when he lets go it blows onto his hands, he holds it against the wind, laughs and looks round, apparently at the watching adults just off-camera. He continues to try different things, placing it on his head, on the outside of the tunnel then holding it on the ramp with both hands for three to four seconds and sliding it down before letting go, it blows again onto his stomach, he again turns but doesn't laugh this time, perhaps because there is no audience. He repeats this three times with slight variations but less apparent interest, his fingers in his mouth, before moving away (53.30). He shows only mild interest in other activities until the end of the session (55.35)

'Conference'

Michael says he liked the skeleton and the wind when asked but otherwise doesn't participate.

Comments

For five minutes (34.35-39.40) Michael explored the Wind Tunnel; it was a game, enjoyment of the sensations but also appeared to be a deliberate attempt to see what would happen when he tried different things. At one point he picked up a little girl and held her so the wind lifted her skirt, both of them laughing; this was observed by a number of adults, including myself (field notes), but not unfortunately caught on camera. Michael appealed to adults to watch what he was doing, and when his teacher joined in on his terms this maintained his exploration. An LSA taking control in order to give another child a turn caused Michael to lose interest.

Follow-up 1

The first follow-up session recorded for Michael took place two weeks after his first visit to the ISC during the first year of the main data collection phase (Cycle 3).

Michael is not present until more than half an hour into the session, he shows some interest in the activities that have been brought but is not seen participating actively until 40.00, when he is rolling a ball down the Tilting Gutter, taking turns with other children. He shows mild interest in other activities then at 41.55 is at the table with the cars, card and hair dryer. His teacher is holding the hair dryer, Michael is watching intently. He is invited to take the hair dryer and turn it on but needs help to do so. When it is on he holds it so the air goes in his face and hair then points it at the teacher and another child and again at the teacher; she says, '*no*' and he points it back at his own face. H1 comes over (42.45), squats by Michael and touches a car, he points the air at it and it moves, then points the hair dryer at his own face again, he jumps and they both laugh. H1 asks Michael if he remembers the cars at the ISC, he gives no verbal response but laughs then looks at the hair dryer again and walks away (43.20). Michael watches an LSA lift two spoons with a magnet and reaches out to take them off but only really

becomes actively involved again when he returns to the cars (45.50). The teacher is at the table with him, trying to encourage him to place a piece of card in the air stream but as he holds it horizontally there is little effect. Michael holds a car in the air then places it on the table and appears to want the teacher to move it with the air. He is off-camera briefly (46.40 – 47.0) then is seen holding a small piece of card in the air stream, the teacher mimes to him to hold it vertically, Michael does so then lets go, the card blows a little way, Michael smiles up at the teacher and does the same thing again, claps and moves away. He walks over to a soft chair and sits down but an LSA goes over and takes him by the hand to the Tilting Gutter. He stays with her at this activity until the end of the session (50.45) but only shows real interest or attempts to adapt what he is doing to get the ball in the bucket for about ten seconds of a two minute sequence.

School 2

The second school session recorded for Michael took place during the second year of the main data collection phase (Cycle 4). The teacher had misunderstood and thought I was bringing activities as for the follow-up session so was unprepared.

For the first thirteen minutes of the session the children are having their snack then H1 asks them if they remember their visit to the ISC. When Michael is asked if he remembers, he says he does; his teacher asks what he liked then says, *'You liked the wind, putting a piece of paper in front of the wind, didn't you?'* Michael says something inaudible but is clearly animated and points across the room. The discussion continues with the other children, Michael turns on his chair until he is told to sit up. He looks up when the skeleton is mentioned but doesn't participate in the discussion about it.

Fifteen and a half minutes into the session the teacher tells the children to bring their chairs to the other side of the room; Michael is slow to follow the others. The teacher says they are going to do some revision, like big children, and asks them to name a farm animal (17.20) then moves on to pets (18.25). Michael sits quietly while others are speaking, mostly looking at the floor, occasionally at the speaker. He only participates when specifically addressed (20.00): Teacher: *Michael, have you got any pets? Have you got any animals in your house?* Michael: *Dog.* Teacher: *Mm, that's granny's dog isn't it? Can you sit up.* Michael stands, perhaps

having understood 'stand up'. Teacher: *No, sit down, sit nicely* (she demonstrates and Michael complies). *Sit nicely. You haven't got any pets now have you? No guinea pigs?* (she consults with an LSA). Michael: *Guinea pig*. Teacher: *No, they've gone*. The teacher turns her attention to another child, Michael sits quietly again until 21.00 when he becomes a bit 'fidgety', looking round, moving on his chair. The teacher addresses him again at 22.00. Teacher: *Right, Michael, can you think of an animal that we've been talking about? What about an animal that lives in the sea?* Michael: (sitting up): *Sea*. Teacher: *What? What animal? Look at the pictures* (she points, Michael turns the wrong way) *no, not those ones, over there behind H.* (Michael turns the right way). Michael: *'Pider*. Teacher: *A what? It's not a spider, it's got eight legs, lives in the sea, what is it? It's a ...?* Someone says '*Optatus*'. The discussion moves to other children and Michael sits quietly again, occasionally looking around. He only shows real interest when the teacher gets a toy spider (27.20). She asks him '*Michael, how many legs has a spider got?*' M: *'Pider*. Teacher: *Legs, how many?* (Michael signs spider). Teacher: *Count* (she touches the legs one by one). Michael counts to eight. Teacher: *Eight, same as a ...* Michael makes the sign for octopus. He remains interested until the spider has been put away then ceases to obviously pay attention again. The teacher gives the children cards showing 'mini-beasts' and asks them to say what they are. Michael shows some interest when one of the children is given a picture of a worm but otherwise sits still showing no particular reaction until 34.0 when he asks something about another child's card. He gets up and points and the teacher says, '*They're little bugs*', he says, '*Yeah*' and laughs. He is invited to choose a card while he is there; the teacher asks what it is, Michael hesitates and she says to the others '*Could you sit nicely and listen to Michael because that is what we're trying to do at the moment, isn't it? Sit and listen to each other*'. Michael hands the card back, the teacher tells him to turn it round and tell the others what it is, he doesn't respond. Teacher: *What is it?* (she shows him the picture again), Michael smiles but doesn't speak. The teacher beckons to him and whispers in his ear. Michael: *'Nail*. Teacher: *Snail*. Michael: *Snail*. Teacher: *Well done*. Michael smiles at the camera and sits down again until 37.40 when the children are told to put their chairs back at the table and come and sit on the floor; Michael is the last to respond again. When they are sitting in a circle on the floor (41.20) the teacher says they are going to build a tower (with foam bricks); she tells each child how many bricks to use then tells them to choose another child and tell them which part of their body to use to knock the tower down. Michael watches until it is his turn (48.40) when he carries out the teacher's instructions for building his tower with enthusiasm for a little over a minute (48.40 – 49.50) then watches intently while another child knocks the tower down. The session ends at 51.10.

ISC 2

Michael's second visit to the ISC took place during the second year of the main data collection phase (Cycle 4).

Michael spends a good deal of time during this second visit 'twiddling' a tape measure or pieces of string, frequently doing this with his head on a table and his thumb in his mouth if left to himself. Staff try unsuccessfully to interest him in other things (13.15, 17.25), pupils and staff try, also unsuccessfully, to take the tape measure (23.30, 24.20, 29.00) and eventually an LSA takes it away (29.40). He has shown only brief interest in other activities in the first thirty minutes of the session: he tries a piece of card in the wind from the Wind Tunnel (1.05 – 1.10) then goes and sits under the Pulleys, jiggles the bucket then places it on his head but is told to take it off by an LSA. He holds a piece of string against the skeleton's spine (11.55-12.10), and at 19.20 moves to the Thump-Wave, hits the drum, skips to the clown, looks up at it, pulls the clown's shirt and jumps up and down but then (19.30) stands with his back against the clown's shirt, twirling the tape measure, rocking, his thumb in his mouth. He resists H1's attempt to interest him in the Thump Wave again (24.50).

From 30.40 he shows a little more interest in the activities, particularly the Thump Wave, the Skeleton (pulling on the leg-bone) and the Disembodied Leg which he makes kick, looking at his teacher, but these are all very brief apart from a short playful interlude (35.30-40.20) when he is making the leg kick and laughing. There is none of the sustained exploration and enjoyment he showed with the Wind Tunnel on his previous visit. When asked which he liked best during the 'conference' (44.30) he says 'ske'ton'.

Follow-up 2

The second follow-up session for Michael took place three weeks after his second visit to the ISC in the second year of the main data collection phase (Cycle 4).

At the start of the video Michael is seen using the chair-back Tilting Gutter with another pupil (Joe), taking it in turns to roll balls down towards a bucket, H1 is with them. Michael is fully focused and clearly working to a goal, shown by his triumphant gesture when the ball goes in

the bucket. At one point Jo tells Michael to move the bucket, he does so but in the wrong direction. When Joe moves away H1 takes his place, holding the gutter for Michael to roll the balls down. She asks if he thinks the heavy ball will go in, he doesn't reply but rolls it and when it does gives a triumphant '*yeah!*'. H1 attempts to get Michael to say what needs to be done by holding the gutter at a ridiculous angle or moving the bucket much too far away and asking him to tell her what to do but he doesn't respond. Michael nevertheless remains focused for nearly five minutes at this activity until H1 moves away when he does so too. Michael is equally involved (on camera for one and a half minutes) using the dominoes with Joe; he frequently knocks one before all are set up but it is unclear whether this is deliberate or not. There is very little sign of frustration on his part or on Joe's.

Comments (all sessions)

Michael is more engaged with the activities during this follow-up session than he had been on his last visit to the ISC and was perhaps simply tired on that occasion. He had also spent more time 'twiddling' towards the end of his first visit.

4.2.6 Richard

Pen-portrait

Richard was in the same group as Gemma and Alan and was seventeen at the time of his first visit to the ISC. His 'statement of special educational needs' noted that he had learning difficulties due to Soto's syndrome. His most recent college report stated that he had some knowledge of basic science facts, for example simple features and properties of common materials. He had attended a rural science course and the report from this noted that he could perform simple practical tasks when given very specific instructions but that he showed little evidence of natural curiosity. He was said to require guidance to choose appropriate tools. The report also noted that he tried to do as little as possible and lacked confidence and motivation and had poor concentration, also that he needed time to achieve. Richard had been on work experience placements: in a fast food outlet, washing up, grating cheese and wiping tables and in a supermarket, stacking shelves and washing-up.

Interview with Richard's teacher

Richard's teacher felt he didn't do as much as he was capable of:

Richard is in his second year now and he's fairly lazy and disinterested most of the time but he's a lot more able again, but he won't use it, he won't tap into it, he just sits there and dreams away and during tea break he wakes up and runs around and takes part. He could do a lot better but he chooses not to, it's infuriating... You keep telling him, you know how not to behave and what not to do and then it works for a couple of weeks and then he gets back into the old routine.

Watching the video of the students re-potting tomatoes, she said: *'I mean*

Richard is doing quite well there, I don't know how much prompting he gets, I

mean once they know the routine they should be able to do a simple task like that but he will just stand there and just wait for instructions'. She seemed to attribute Richard's lack of motivation, at least in part, to his parents not giving him enough independence: *'They don't give him as much independence at home or let him do things, which is bit of a shame and that's why he sits around. .. he'll wait until somebody says do it, we have to go and tell him, he just goes off in a dream'*.

Description of sessions

College 1

The first college session for Richard took place in the first year of the main data collection phase (Cycle 3). He took part in the same Christmas card making activity as Alan and Gemma.

During the discussion of the previous lesson Richard mainly looks at the speaker, occasionally down at the table, and at first avoids answering the teacher's questions even when directly addressed (5.45): Teacher: *See if Richard can remember? What colour were the stars?* No response, Richard looks away. Another student volunteers *'yellow'*. Teacher: *They weren't really yellow were they? They were the same colour as your crayons, weren't they? What colour do you call that?* Richard: *Gold*. After this exchange the teacher addresses another student and Richard looks down, then watches the teacher again, yawning from time to time. There is an occasional whispered exchange between Richard and the LSA next to him but he again looks down when the LSA prompts him to respond to a further question from the teacher (19.00). When directly asked Richard volunteers a guess at how many cards could be made in the session (23.05). Once the card-making activity is set up Richard does nothing until given specific directions by the teacher.

Comments

In thirty minutes of discussion Richard participated twice and only occasionally showed clear interest; he often looked at the speaker but it was not possible to tell whether he was really listening. In the practical section of the lesson he followed directions but did not do anything on his own initiative.

ISC 1

Richard's first visit to the ISC also took place in the first year of the main data collection phase (Cycle 3).

Richard shows active interest most of the time as the activities are demonstrated at the beginning of the session, moving so he has a good view, although he doesn't respond to questions put to the group as a whole. When the group is invited to have a go at whatever they like, Richard moves to the Water-Lift without hesitation and begins to turn the handle. He later wanders around for a short time, goes to an activity suggested by staff but moves away again when joined there by a fellow-student. He returns to the Water-Lift and is seen there shortly afterwards (10.0) turning the handle with enthusiasm, an LSA standing by him. At 11.55 Richard has joined Gemma at the Giant Dominoes, Gemma is directing and Richard is doing as she says. The teacher comes over and tells Gemma to let Richard do it and then questions him about what he has been doing; he responds verbally but doesn't do anything. When the teacher withdraws Richard looks again to Gemma for instructions. At 20.55 H1 asks them if they want to try something else. Gemma asks Richard what he wants to do, he looks at her with exaggerated attention, and seems more interested in her than in the activities. They continue for a short time at the Giant Dominoes then Richard moves to the Disembodied Leg and shows mild interest in making this kick. At 24.30 the teacher asks Richard what he wants to do next and he chooses the Wind Tunnel where he rolls a car down the slope (at the teacher's suggestion). He is off-camera from 25.45 to 31.20 then at the

Tilting Gutter: Sam (fellow-student) invites him to have a go and directs him until 33.50 when he is off-camera for the rest of the session.

Comments

Richard appeared interested throughout but not motivated to do a great deal independently.

Follow-up 1

The first follow-up session for Richard took place three weeks after his first visit to the ISC in the first year of the main data collection phase (Cycle 3).

Discussion session

Richard responds to a general question about whether the students remember coming to the ISC, then turns his attention to papers in front of him until 4.15 when he is asked a direct question about what he remembers; he says the skeleton on the bicycle. As soon as another student is addressed (4.40) he returns his attention to his file. At 7.40 H1 asks Richard if he remembers anything else, he says, 'No' but then mimes turning the Water-Lift handle to an LSA; she tells him to tell H1 and he says, 'Water'. When asked what he did with the water and he says 'Turned the wheel'. H1: *And what happened?* Richard: *Water came up.* H1: *Right, and then?* (two second pause) *What did the water do when it was at the top?* Richard does not respond and another student answers.

Activities

At 8.55 H1 suggests Richard use the dominoes with Gemma but neither move until specifically invited to do so. Gemma gives instructions to Richard who does what she says but stops doing anything when not told what to do. They are working together to a goal but rare attempts by Richard to take the initiative are rejected by Gemma. Again Richard shows more interest in Gemma than in the activities, smiling at her, stroking her hair and calling her 'Cheeky'.

College 2

The second college session recorded for Richard – re-potting tomatoes in the greenhouse - took place in the second year of the main data collection phase (Cycle 4).

For most of the session Richard carries out directions either from the LSA or from Gemma. He is occasionally working to a shared goal with Gemma but still carrying out directions given previously. When he is not doing this he watches what is going on with interest, occasionally looking around, his attention less obviously focused.

ISC 2

Richard's second visit to the ISC took place in the second year of the main data collection phase (Cycle 4).

Gemma is very much in charge again but occasionally allows Richard more initiative, for example taking up his suggestion to alter the slope of the board to which the Giant Dominoes are attached (1.45 – 2.40). Richard also occasionally directs Alan (3.10-3.15). At the Motion Detector Richard watches then follows directions from H1; he doesn't seem to understand the principle at first and doesn't move at the appropriate time until told to do so by H1. When later he tries to do so he is called back by Gemma and complies when she tells him not to move, although this means there is no point to the activity. He is a little more resistant to doing exactly what Gemma says than previously, however, and shows himself willing and able to do things independently on this occasion when H1 invites him to go to the Wind Tunnel, distracting Gemma from following by asking her about what she has been doing (53.25). Richard goes over to the Wind Tunnel, looks in, switches on and rolls a car straight in. He goes and gets a differently shaped car and rolls this down too. He begins to walk away, then retrieves the second car and rolls it down again, goes and gets a third and rolls this too. He walks over to the table, looks briefly in the box (of card and sellotape) then back to the tunnel where he retrieves all three cars and rolls them down the slope one after the other, watching them go down; he takes two out again and rolls them once more. At this point Alan comes over and looks in the

tunnel, Richard speaks to him (inaudible) and points into the tunnel. Alan reaches in, Richard moves away. He has not shown huge interest or adapted what he was doing to any extent but is willing enough to do things independently. Richard later returns to the Wind Tunnel (65.40), rolls each car in turn then takes them out again, twice. Again he doesn't appear to be paying much attention to what is happening or to the differences between the cars; however one has card attached to it that is lying flat so not affecting the car's movement and he goes off-camera (perhaps to a member of staff) and returns with the card fixed upright. He places the car on the slope and it remains stationary at the top of the slope; he smiles, waits a moment, then rolls the other two which carry it down with them. He wanders around a moment smiling - he appears to be aware that something different has happened - then rolls the car with the card again; it goes halfway down the slope, he waits a moment then rolls the other two either side. Richard rolls all three again, twice in quick succession, puts one in backwards, looks into the tunnel once or twice but doesn't really appear interested in differences between them or to be experimenting deliberately.

Comments

Richard showed more initiative once he was on his own but generally seemed quite happy to follow Gemma's directions and clearly enjoyed being with her.

Follow-up 2

The second follow-up session for Richard took place two weeks after his second visit to the ISC, also during the second year of the main data collection phase (Cycle 4).

Discussion session

Richard makes no attempt to participate in the discussion until directly addressed. When asked if he and Gemma can remember what they did at the ISC, he looks down at first as if avoiding answering but then says he remembers the 'bricks'. When he is asked what he did with them the following exchange takes place:
Richard: *Put 'em up.* H1: *And then what?* Richard: *Knocked 'em down.* H1: *What happens when you knock them down?* Richard: *Make a crash.* Gemma joins in, Richard yawns and ceases to participate until H1 mentions the Wind Tunnel and Richard says he used it. H1 asks if he put something on the cars, he replies,

'cover'. H1: Cardboard cover, yes. And what did that do? Richard: Fell off again.

Activities

Richard immediately shows interest in the dominoes H1 has brought and starts to set them up without being told. Most of the time he spends using them (5.40 – 16.20) he is seen from the back view only so his responses are not clear but he is obviously interested and co-operating with Gemma. From 16.20 Richard is on his own at the Tilting Gutter, he makes slight adjustments to the tilt of the gutter as he rolls the ball but doesn't show great interest in what he is doing. At 17.50 he walks away, H1 asks if he got the ball in the bucket, he says, 'Yes', she asks if he can show her again, but is called away before he can do so. He picks up the ball and places it in the other end of the gutter, the gutter falls and H1 replaces it, Richard places the ball on it at H1's request but makes no attempt to adjust it, only doing so after H1 has moved away, this time making the appropriate adjustment so the ball goes in, this is repeated, then Richard walks away. At 27.0 he joins Alan at the magnet, sitting down beside him, and puts an iron bar in the coil; it is pulled right in and Richard looks in the other end. Richard puts a spoon in then pulls on it, perhaps intending to pull the bar out with the spoon but the spoon comes away from the bar. Richard says something inaudible to Alan then tries again with the same result. He picks something up (foil or lead?) which he holds to Alan's face, Alan kisses it, this is repeated several times and both laugh. Richard puts the spoon in again, pulls the bar half out and repeats this several times until he succeeds in getting the bar out. Richard is leading, showing more independent initiative; he encourages Alan to feel the end of the bar, which has been heated by the solenoid, he taps the solenoid and Alan switches off. Richard puts the bar in again then switches on, the bar is pulled in and he again uses a spoon to pull it out. He switches off then tries the spoon alone, he switches on, the spoon is pulled in, he talks to Alan about what is happening, looks in, apparently curious about what is happening; he says, *'It's in there'*. When H1 comes over Richard says the bar is *'stuck in there'*, but this is clearly a joke as he turns the solenoid off, pretends to try to pull the bar with the spoon, then turns it on again and pulls the bar out. H1 talks about the forces involved; there is no response from Richard.

Comments

Like Alan, Richard is more independent when he is not being directed; here he showed an inclination to collaborate, play and explore.

4.2.7 Jackie

Pen-portrait

Jackie was fifteen at the time of her first visit to the ISC. Her 'statement of special educational needs,' revised shortly before that time, described her development as severely delayed in all areas. It also noted that she was ambulant but suffered from 'intentional tremor,' which 'caused problems physically and mentally'. She was said to be clumsy in gross motor movements but that her patience and perseverance helped her to achieve her aims. It further noted that she had great difficulty with all fine motor skills including writing, in which she showed no real interest.

Her statement described her as friendly, and noted that she could say '*hi*' and '*hello*' and twenty clear words or phrases. Her comprehension had been assessed as being at a one word level, expressive language one to three word phrases. She was said to have limited concentration and to be easily distracted but if interested would give her full attention for a sustained period. The 'statement' described her as unaware of danger but noted that she did take notice of verbal instructions and if told to 'sit down etc' would usually comply. She was said to need firm and consistent handling at all times to keep her out of danger and encourage appropriate behaviour.

Her school report, written around the time of her first visit to the ISC, described her as an active participant in all areas of the curriculum. In English (speaking and listening, reading and writing) she was said to be very interested in watching communication between others and to maintain good eye contact. It said that she would initiate conversation and was aware when it was her turn

to respond but didn't always do so. Jackie was said to know the meaning of several Makaton signs but to need prompts (verbal and physical) to use them. She could carry out simple, structured requests and used a communication books with symbols and photos to which she could point. She could write her name with physical help and used a concept keyboard and mouse to communicate meaning through pictures, although the report noted that she clicked the mouse but had difficulty relating the mouse to the arrow on the screen. She was said to enjoy science, to be motivated and usually concentrate well and with verbal and some physical prompting to be able to follow simple instructions to set up experiments and collect apparatus from around the laboratory. The report noted that she could follow rules of health and safety in the laboratory and with only a little help could sort pictures of living things.

Interview with Jackie's teacher:

Jackie's teacher remembered how Jackie had responded on her first visit to the ISC although this was not the video that was used for the interview: '*And one time she did (do a lot), do you remember? When she got the circuit, um.. that was just wonderful.*' The teacher also noted that the follow-up session had shown that Jackie had remembered what she had done at the ISC.

Description of sessions

ISC 1

Jackie's first visit to the ISC took place during the second preliminary study (Cycle 2) with activities relating to Energy and Electricity.

At the start of the session at the ISC, when the activities are being introduced, Jackie's attention appears to be focused on them only intermittently, for example when the LSA takes her hand to show her how the fish move (8.00). She becomes more involved after twelve minutes when she is taken to the Circuits and the movement of the spinner is demonstrated (12.20).

With adult encouragement Jackie is able to make the spinner turn for herself. At first she jumps when she succeeds in plugging it in (13.45) as if she had not expected this. Shortly afterwards it is clear that she knows what effect to expect, and that she intends her action to produce it, from the satisfaction and pleasure she expresses both verbally and non-verbally each time she succeeds in making the spinner turn (14.10, 14.50). At first the effect is only intermittent as she is unable to get the lead to stay plugged in but she persists, although this is clearly physically difficult for her. Her response when she succeeds in getting the lead to stay in (38.20) makes it clear that this was indeed her goal.

Altogether during the visit Jackie spends at least fifteen minutes at the ring circuits (it may be considerably more but with only one video camera it is not possible to tell) and during this time her attention is actively engaged throughout, except when another pupil intervenes (36.30 – 38.00). Although he too makes the spinner turn, Jackie shows none of the interest she has shown when she achieved the same effect herself. Being in control appears to be a strong motivating factor for her.

Follow-Up 1

The first follow-up session for Jackie took place four weeks after her first visit to the ISC in the second preliminary study (Cycle 2).

Jackie is presented with the Transistorised Light Box: she immediately takes one of the wires and tries to plug it into a hole in the box. Despite demonstrations that the two wires need to be held together to make the light come on, she persists through most of the session in trying to plug the wire in as she had done with the ring circuits at the ISC. Only at the end of the session (37.33) does she show a willingness to collaborate with the helper in holding the two wires together and pleasure at the result.

Comments

Jackie showed clearly that she remembered what she had done at the ISC but had difficulty in making use of this and adapting it for a new situation.

School session

Jackie was in the same group as Karen and Bill and was also present for the session on melting in the mainstream school science laboratory in the first year of the main data collection phase (Cycle 3).

Jackie sits at a table with another student and an LSA, showing no particular response to what is happening for the majority of the session when she is on-camera. At 6.35 the LSA shows her the worksheet, Jackie doesn't respond but when the LSA says something and points across the room (perhaps asking her to get equipment) she gets up and wanders vaguely around the room for one minute before returning to her seat and to sitting doing nothing. At 9.15 the LSA asks her again to get something and she goes more confidently this time, returning, smiling, with two pairs of goggles; she hands one pair to the other student and puts hers on with help from the LSA. From 11.10 she sits again showing no interest as her fellow-student and the LSA prepare the equipment. She is off-camera for a considerable amount of time until 32.35 but whenever she is seen she is just sitting, sometimes gently rocking. From 32.35 to 33.0 she is more animated, pointing at the equipment and again from 38.50 to 40.20 when the fact that something is melting appears to have been pointed out to her. At 40.30 she has returned to simply rocking but at 40.50 she is invited to look at the chocolate that another group has been melting; she goes over with the teacher but seems more interested in the other students than in the experiment. From 44.55 to 45.20 she helps to put equipment away. She does not take part in the discussion about the experiment in class afterwards.

ISC 2

Jackie's second visit to the ISC took place in the first year of the main data collection phase (Cycle 3) with activities relating to Forces and Movement.

On her second visit to the ISC Jackie never shows the same degree of involvement that she had with the circuits. She spends most of the time watching the others, apparently with great interest, pointing from time to time and saying '*look*' but not joining in. An LSA takes her to the Thump Wave (21.45) and guides her hand to hit the drum, pointing at the clown moving in the air from the drum. Jackie smiles but moves away as soon as the LSA leaves. Later (36.0) the teacher demonstrates the effect of the Thump Wave again, with an exaggerated gesture of surprise as the wind ruffles the clown's shirt and again Jackie points and smiles but when encouraged to have a go herself stands with her back to the clown while hitting the drum and, even when encouraged to turn to face it, looks at the drum rather than the clown and it is not clear whether she has really understood the link between the two. Similarly, she tries items in the Electromagnet while H1 is standing beside her and encouraging her (44.25) but turns to watch the others again as soon as she is left on her own (45.10).

Follow-Up 2

The second follow-up session for Jackie took place three weeks after her second visit to the ISC in the first year of the main data collection phase (Cycle 3).

Jackie makes no contribution to the discussion at the beginning of the session even when directly addressed. At the start of the active part of the session (2.05) she is putting something in the Electromagnet and says, '*Good, good*', but a few seconds later (2.25) places her hands in her lap and looks around. H1 pulls the iron bar in and out of the magnet, Jackie watches; H1 gives her second bar and she places it in the other end, clearly knowing where to put it, jumping slightly when it '*clicks*' onto the first bar. H1 pulls on the other bar so Jackie can feel the pull but she lets go. H1 then passes her a metal spoon and puts other items within her reach then moves away. Jackie picks up a small magnet with the spoon then puts the

spoon into the Electromagnet; it is pulled onto the bar and Jackie pulls it gently, then holds it in the magnet but turns to look out of the window, distracted by something outside (3.25). She takes the spoon out of the magnet and looks across the room. At 3.50 H1 returns, Jackie says '*It's good*'. H1 encourages her (by gesture) to try other things in the magnet. Jackie tries to push something else (lead?) in with some difficulty (4.10) but then just looks around with variable interest at what the others are doing for the rest of the session.

Comments (all sessions)

Jackie's tremor appeared to have got worse in the time that separated the two visits to the ISC and it may be that her physical condition had deteriorated. It may also be that the new activities did not allow for the sort of control that had clearly pleased her so much with the circuits on her first visit. Cause and effect was often physically separated (the drum and the clown at the Thump Wave) or invisible (the Electromagnet) making these activities less accessible for Jackie.

4.2.8 Louise

Pen-portrait

Louise was eight and a half when she visited the ISC. Her 'statement of special educational needs' described her as very friendly, with a good sense of humour; she was said to enjoy 'integrating' into a mainstream class one afternoon per week. It also noted that she had Down syndrome. Her school report from around the time of her visit to the ISC noted that her drawing of a person consisted of a head plus lines (limbs). In English she was said to participate as a speaker in a group but needed to think not just comment on anything. The report said that she enjoyed listening to songs and stories but was easily distracted, with quite a low attention span. She was aware that symbols and print carry meaning and could point to and recognise her name and write a few letters. Language assessment had indicated comprehension at a two information-carrying word level (greatly increased by signing). It was noted that she often concentrated on the last word said and forgot the rest. Expressive language was assessed at two or more words in informal situations, single words in a formal situation unless prompted. In maths she could rote count to 5 (usually), with one to one correspondence to 3 and could sort three groups of different sizes if the difference was very obvious. In science she could point to and name external body parts, and leaves and petals on a flowering plant. She could name a variety of animals and knew where some live and could indicate if materials were rough or smooth.

Interview with Louise's teacher

Louise's teacher said that her understanding was 'very low', adding:

Her social understanding is great and you can think she understands a lot but if you actually sit down and you're working with her, asking her questions, her understanding's incredibly poor ... we're not totally sure whether a lot of it is

just the concentration ... very easily distracted, um, but very good at joining in 'cause she wants to join in... Louise and Joe are both very good at playing, they can go and either amuse themselves without toys or they'll play with toys.

Description of sessions

All sessions recorded for Louise took place in the first year of the main data collection phase (Cycle 3 of the research design).

School session

Louise is asked about what she did at the weekend (the teacher has her home-school book); she needs a lot of prompting to say what is in the book. After this the children write or draw their news; Louise copies intermittently in her news book when prompted. In the next part of the session the teacher is discussing the class topic of toys with the children. Louise looks at the speaker, she is attentive, putting her hand up to answer questions, until thirty-six minutes into the session when she begins to look around and yawn (she has been sitting still all of this time, watching and listening). When the children are told to get up and move, Louise sits still until told individually (42.05).

ISC

Louise is attentive during the demonstration. When the children are invited to choose an activity (5.30) she runs to the Thump Wave and hits the drum with enthusiasm, watching the clown and tries to adjust the position of drum. She is off-camera for a while, seen briefly at the Giant Dominoes then at 7.30 returns to the Thump Wave, hits harder, waits, watching the clown. There is no effect because the drum is wrongly positioned, Louise looks in the drum, perhaps puzzled about why nothing happened. A helper adjusts the drum and invites Louise to try again; she does so, but there is still no effect and she moves away. Louise watches others for a while then from 12.10, collaborates with an LSA at the Tilting Gutter, making slight adjustments to get the ball in the bucket. From 19.30 she again shows close interest in what is happening at various activities without participating. She goes to the Wind Tunnel, and is clearly enjoying the sensation of the wind, putting her face and hands in it, then her ear to the tube the wind is coming up (24.25 – 24.50). At 25.50 she takes a loose domino to the Thump Wave drum, places it in drum and looks in. Another child hits the drum while Louise's head is in it, she smiles then watches the

clown, goes over to it and looks up at it, smiling. She participates briefly at the Dominoes and the Tilting Gutter, more often she watches others with interest, moving quickly from one thing to another.

Follow-up

The follow-up session took place two weeks after the ISC visit.

Louise looks quickly at a number of activities to begin with, then from 1.55 to 2.40 she is working co-operatively at the Tilting Gutter with another child; her gesture of triumph when the ball goes in the bucket shows this was her goal. At 6.15 she is looking intently at the Electromagnet; she places a metal object in it, looks into the coil, reaches round and repeats from the other end. She remains there for five minutes (off-camera part of the time). From 9.25 she is again working collaboratively at the Tilting Gutter then from 11.20 to 14.20 with an LSA and another child with the Giant Dominoes; the LSA takes most of the initiative but Louise joins in willingly. From 14.20 to 14.50 her teacher directs her at the dominoes; H1 asks a question about why the dominoes fell and is ignored.

Comments (all sessions)

Louise was enthusiastic and engaged throughout the ISC and follow-up sessions, enjoying sensations such as the wind from the Wind Tunnel. She did not stay long at any particular activity and did not often make adjustments to achieve a goal. Her intention in placing the dominoes in the Thump Wave drum was not clear and may simply have been playful.

4.2.9 Alex

Pen-portrait

Alex was only six and a half at the time of his visit to the ISC. A recent 'statement of special educational needs' noted that he had greater difficulty than most children his age in understanding language and in acquiring cognitive skills but gave no reason for these difficulties. Alex was said to have good understanding of everyday routines and of instructions and requests at a two-word level, but could not yet make all speech sounds and used signing. He was also said to have a significant degree of hearing loss. His 'statement' noted that he needed close supervision to participate fully in a group and needed adult support to play appropriately and imaginatively.

His school report noted that he had begun to copy below letters and identify a range of symbols and to match words. He could count with one to one correspondence to five. In science it was noted that he could identify some animal noises, point to most external body parts, name some basic fruit and vegetables and some animals, say whether a material is hard or soft, and understand that things can be moved by pushing and pulling.

Description of sessions

All sessions recorded for Alex took place in the first year of the main data collection phase (Cycle 3 of the research design).

School session

Alex looks at the speaker or down while others (teacher or fellow pupils) are talking about farm animals; it is not possible to tell how much attention he is paying. He occasionally looks round at the camera. The next topic of discussion is pets; when asked (18.40) if he has any

animals at home or on the farm he shakes his head but when the teacher asks '*Haven't you? What does mummy ride?*' he signs '*horse*'. The discussion moves on to other children and again it is not possible to tell how much Alex is taking in. Later (23.55) he is asked whether he remembers '*that lady who came on Monday and brought those animals for us to hold?*', he nods but when asked what he held doesn't respond. He shows more interest when the teacher produces a toy spider (27.20), particularly when one of the other children puts it on his head, but is told to take it to the teacher and after that again shows little interest until directly addressed. At 32.55 he is asked to identify a picture of an animal; he signs '*lion*', the teacher asks, '*Is this a lion?*'; a number of other children say, '*No*', and the teacher asks Alex again who signs '*caterpillar*'. The teacher says, '*A caterpillar. What does it change into?*'; Alex signs '*butterfly*' and makes to sit down. He is told to come back and is asked to identify another picture which he does correctly as an ant. He is not involved again until the end of the session when the teacher is getting the children to build towers with different numbers of soft bricks and knock them down with different parts of their bodies. Alex is keen to join in and at 44.0 is invited to make a tower with eleven bricks; the children count as he puts them on; Alex makes an exasperated gesture when the tower falls at ten but then builds it up again successfully. He is told to choose someone to knock it down and suggests himself but is told to choose one of the others, which he does then sits down and is not seen clearly again for the rest of the session.

ISC

Alex is first seen at the Wind Tunnel with another pupil, he is standing in front of it with the wind in his hair. The other boy is removing his cars and they smile at each other. Alex puts his car in with two pieces of card attached, one flies off, he turns to watch it then turns back to the car which is stationary on the ramp. He reaches in and gently pushes it downwards, perhaps puzzled that it has not gone down. He jiggles the ramp to and fro then up and down, increasing the slope so the car does run down. He retrieves the car and replaces it on the ramp where it again stays still and he jiggles the ramp until it goes down. He adds sellotape and repeats the process, a helper tries to make a more streamlined shape with the card for him but still the car doesn't go down and Alex pushes it gently, smiling at the helper. At 3.55 he is seated by the Electromagnet putting one iron bar then another into the coil. He collaborates briefly with another child, each holding a bar, but then returns to trying things out on his own, using one object to push others through the magnet. At 7.0 he is pulling on an iron bar switching the magnet on and off as he does so then looking into the magnet, perhaps intrigued by the difference (the pull on the bar is very strong when the magnet is on and, of course, non-existent when it is off). He goes on to pull objects in and out in quick succession

and picks up a bar and waves it about shouting '*Wheee*'. He remains at the magnet until 10.05 when he moves on to the Motion Detector but does not show the same degree of interest.

After a brief time off camera (13.10 – 13.35) he is seen at the Pulleys where he remains actively engaged working towards the goal of raising and tipping the bucket with the ropes in order to get the ball into the gutter until 29.40 (apparently continuously but he is off-camera between 21.55 and 26.40 so this is not certain). He does this in collaboration with another child for much of the time, neither showing frustration when they are unsuccessful. From 29.40 to 32.35 he is off-camera then again at the Motion Detector where he bangs the sensor (perhaps frustrated at being unable to make it work). A helper sets it going and encourages him to move backwards and forwards but then moves away. Alex jiggles his body backwards and forwards but does not walk up and down so produces little result on the screen and does not really seem to have understood how to do so. From 33.15 to 34.45 he is off camera again then seen at the Magnet for one minute, trying things out as before then not seen again until the 'conference.' Alex makes no attempt to take part in this until addressed by name and asked what he liked doing, when he points at the magnet. He is asked what he did and gestures putting something in it, saying '*tick*'. He is asked if he means the stick and nods and smiles (although he may have meant that things stuck?) and is asked, with demonstration, if he put two 'sticks' in at which he nods and smiles again. Another student interrupts and Alex doesn't contribute again.

Follow-up

The follow-up session took place two weeks after the ISC visit.

Alex is using the Tilting Gutter on the chair back at the start of the session. He adjusts the bucket to get the ball in (many of the students do not think of this). When Louise is using this equipment and Alex watching H1 asks him where he thinks the bucket should go, he moves it in the wrong direction but this appears to be a joke. H1 sets up a row of dominoes and asks Alex if they will fall. He says, '*Yes*'; H1 invites him to knock them over and he does so with his foot. He goes on to set them up very carefully in a circle; Louise tries to join in, Alex protests, he gestures to Louise to put hers in the centre of the circle, she does this and they wobble but stand; Alex says, '*No fall, no fall*'. When the circle is complete he fetches the bucket from the Tilting Gutter and places it on the circle. He is off camera for ten minutes then at 20.35 at the table with the toy cars, card and hair dryer (provided instead of the Wind Tunnel) but others are using them. At 24.50 he is briefly using the dryer to move the car, pointing at the card attached to it. He is off-camera for 10 seconds and when on again another

pupil has the dryer, moving the car to edge of table with it; Alex holds out his hand to catch it, anticipating where it will fall. From 27.15 to 28.05 he briefly collaborates with another pupil using the Electromagnet until the other is called away; Alex loses interest and also moves away and is not on-camera again.

Comments (all sessions)

Alex was keen to try things out at the ISC and was actively engaged throughout this and the follow-up session. His communication difficulties appeared to make it very difficult for him to participate in language-based sessions.

4.3 Semi-Structured Interviews with the Participants'

Teachers

Semi-structured interviews with the participants' teachers were carried out using videos of sessions in school or college and ISC visits to stimulate recall as described in Chapter 3. The teachers were asked to comment on individual student's behaviour, particularly in relation to concentration and independence, and how typical or otherwise they felt it to be in each situation. Themes emerging from the interviews are summarised below (Figure 10), followed by examples from interviews with each of the teachers that illustrate these themes. The majority of remarks relating to individual students are included in their pen-portraits. Comments relating to the typicality or otherwise of students' behaviour are summarised in Section 4.3.3. Full transcripts of the interviews are available.

4.3.1 The teachers' views on the students' responses and on teaching approaches

The interviews gave interesting insights into the teachers' views on teaching approaches and their explanations for perceived differences in behaviour in the two settings. A number of themes emerged; these show internal contradictions within all the interviews between behaviour viewed as positive in school/college and behaviour viewed as positive in the ISC, and between methods described as necessary in the students' usual settings and the teachers' views of what had produced the behaviour they saw as positive in the ISC. None of the teachers made any negative comments about students' responses in the ISC, or methods used there, perhaps out of politeness! These are summarised below (Figure 10).

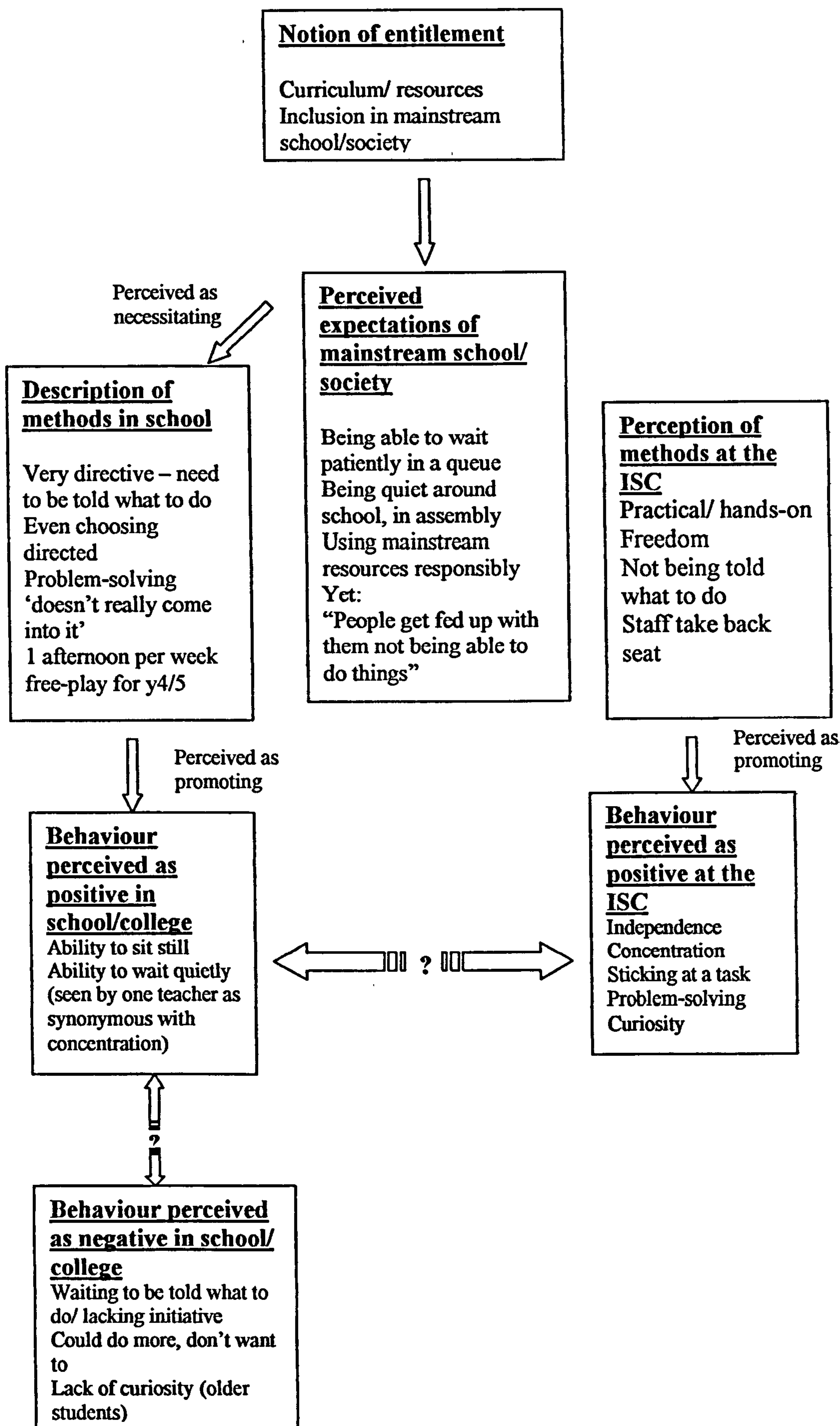


Figure 10: Themes emerging from semi-structured interviews with participants’ teachers

The following are examples from each of the interviews illustrating the themes summarised in Figure 10:

Teacher 1 – College group

Teacher 1 was the oldest of the three teachers interviewed and was from another European country.

Behaviour perceived as positive in college

Teacher 1 appeared to perceive the fact that Gemma '*will get on with anything worksheet wise*' as positive, as she did sitting and listening, although she remarked:

They can't all cope with it and they become disruptive as a consequence, that's why I need so many staff so they can take them out and do something else, more appropriate for them at different times of day. I mean if you didn't have the staffing it would be impossible, because you see their needs are so different. Bob couldn't cope with ... Alan, he's dropping off. ..For Darren to just sit there for a long stretch of time that's quite something.

Perceived expectations of others

Teacher 1 also saw being able to sit and listen, wait a turn as necessary 'socialising':

And then again it's socialising, being able to sit down for ten minutes and listen to somebody, these are skills they need for living out in the community. If you have to wait in a queue somewhere it's no use throwing a wobbly, 'cause it's not going to get you anywhere. These are, even if they're not actually productive at the moment it still teaches them life skills, and listening to other people is something they find very difficult as well ... waiting for their turn

Behaviour perceived as negative in college

Teacher 1 commented a number of times on the students' passivity, viewing this in a negative light, and appeared to feel that the students chose to behave in this way. On watching the video of the group making Christmas cards she remarked:

He (Alan) just stands there waiting, he won't do anything until somebody tells him what to do. He knows exactly what he has to do but he chooses not to. Life is much easier if you get told what to do...

Similarly of Richard she said, *'Oh, he'll wait until somebody says do it ... he could do a lot better but he chooses not to'*. Teacher 1 also commented on the students' lack of concentration in college: *'I mean they can only concentrate for a short period of time really'*.

Methods used in college

As illustrated above, Teacher 1 spoke of the need to tell Alan and Richard what to do much of the time. She contradicted herself somewhat in the approaches she suggested as useful for getting Alan to do things, saying at one point, *'if you get him angry, that's another thing, you get him to do things, if he gets really angry he'll get on and do it, but it needs quite a bit for him to get angry'*. Then later saying, *'if you bully him, he doesn't respond at all well to that.... He's even less likely to do something for you, he's so used to it that in a way it's counter-productive that you have to humour him you know, jolly him along. His eye contact is pretty poor, he always has his head down'*.

Other things said by Teacher 1 give an indication of methods used in college. Of an accredited course she remarked: *'Independent Living, that's another one ... they stipulate how many hours you have to teach that subject'*. And later: *'Problem-solving doesn't come in that much, that's the snag, I mean in cookery sometimes it could'*.

Behaviour perceived as positive at the ISC

Teacher 1 commented on the concentration and perseverance at the ISC as well as the problem-solving abilities shown by students:

We all have noticed differences. We see them in a completely different light, sometimes we think they'll do quite well which they might not necessarily do and others like Alan or was it Darren or maybe both of them are completely hooked on a problem-solving problem, they wouldn't give in, they kept trying and trying, they wouldn't give in ...that's when he'd (Alan) just started with us and he was pretty (?) at the beginning and here he went on and on, trying it out, moving things, adjusting them, total concentration.

Perceived reasons for differences in behaviour at the ISC

Teacher 1 offered a number of explanations for why she thought the students' behaviour was different in the ISC:

Look at his (Alan's) smile, look at his contented smile of anticipation ... nobody interfered, he was allowed to get on and he's working quite fast considering ... That's nice to see him work totally on his own. Ah, look, he's adjusting it. It doesn't surprise me 'cause he will go on and on for a while ...It's a very stimulating environment and it's exploratory, it's hands-on, which they enjoy 'cause when we take them to places it's usually hands off... It's a treat, a new experience and they're allowed to make mistakes and no one tells them off. It's all very practical and visual, isn't it? Playful... 'Cause it's such a novelty for them, isn't it?

Teacher 2 – Secondary age group

Teacher 2, the teacher of the middle group of students, was younger. She spoke a good deal about the students' entitlement and felt that being able to use the mainstream secondary school's resources was a great benefit. However, she was also concerned by the perceived expectations of the mainstream school.

Behaviour perceived as positive in college

Watching the video of the science laboratory session, Teacher 2 commented: *'Their behaviour is more, is calmer in the science lab because they are very aware that they are in a you know, science lab, with dangerous equipment.'* She seemed to be equating concentration with sitting and waiting turns as she went on to say, *'that was good concentration. They are able to concentrate, we do a lot in the morning sessions of communication, talking, waiting turns, sitting ...'*

Perceived expectations of the mainstream school

Teacher 2 spoke of the expectations she saw mainstream staff as having:

[The students] go to registration, they go to assemblies, they have to sit there for twenty minutes and they can't stand up and call out and run around, so there's high expectation .. and if we're walking around school, using the labs and another teacher comes in we don't want the kids jumping up and down, running around, so, well, we wouldn't get to use them ... they know their behaviour has to be good, immaculate, because they would be out of the lab like that, because of the health and safety.

Behaviour perceived as negative in school

Teacher 2 talked about individual students' lack of concentration (Karen and Bill) or aggression towards others (Bill) as described in their pen-portraits.

Methods in school

Teacher 2 emphasised entitlement and being able to use mainstream resources:

Access to the resources – you don't get those in special schools.. They love it [the Science laboratory]. And even the displays, although they're geared to the mainstream students, they're still appropriate and they will pick things off the wall which they can deal with ... even if they just learn the buzz word, if they see something on TV, they know what a Bunsen burner is, they know what Hinduism is, or whatever it is, it gives them confidence.

Of the session in the laboratory she said:

That looks very difficult but the fact is that they're using the different equipment even if they don't grasp the concept, they're using a variety of resources, they're responsible for those resources and health and safety, getting them out and putting them back and those are basic skills so they're going to get those even if the concept is too hard.

She felt that some of the students would find transferring the concept of melting difficult from the work in the science lab but added, '*through pure reinforcement we can teach it*', saying that the whole term had been spent on the concept of melting in a variety of ways including cooking.

Teacher 2 felt the students' concentration was good in the science lab, although their attention had rarely seemed engaged in the video recording of the session (see accounts for Karen, Bill and Jackie). She attributed this to the multi-sensory nature of the experience:

They're probably, because it's such a physical thing, sensory, you know, you had something to look at and you had the smell of different things burning, their concentration would be better, was better ...so probably better than it would be if you sat down doing counting or maths.

She felt however that the students might have been distracted from the experiment by the worksheets:

I don't know how useful the worksheets are ... they're having to do an experiment and record it ...I don't know if it's actually reinforcing what they're doing 'cause it's distracting them from... I don't know if their concentration on the experiment would be better, more focused, if they didn't have to think about, even if it's just ticking a box ...there's the health and safety, goggles on.. it's a lot of sort of different things coming at them, I think they all knew what they were doing which is good.

Of the students' independence she said:

It's always directed so even with independent choice we've directed it and you'd only maybe have a small choice, you wouldn't have a big choice like there, like all those different things and no direction .. independence of choice is very

structured but we are at fourteen trying to bring in more opportunity to have a bit more freedom but it's difficult 'cause ... some of them do just sit there and do nothing if you don't direct.

Behaviour perceived as positive at the ISC

Teacher 2 remarked with pleasure on the degree of concentration and perseverance shown by Karen (see pen-portrait), attributing it to the fact that *'here she's on her own.. She's not getting the attention here, so she is left to run everything.'*

Watching Jackie's lack of interest in the Electromagnet, she recalled how interested Jackie had been on her previous visit by the Circuits, adding *'she's obviously more responsive to a visual stimulus like that than the magnetic one which was more...'*

Watching Bill and John playing with the Electromagnet Teacher 2 said that this was unusual and that they didn't get on very well.

Perceived reasons for differences in behaviour at the ISC

Teacher 2 suggested the lack of worksheets to distract at the ISC as one reason for differences in behaviour but also:

The freedom to explore and not be inhibited to explore ... nobody has interrupted them and said 'don't do that' ... how often do they get that freedom? Independent, doing it themselves because we as helpers or staff had to take a back view and maybe gently structure or prompt ... they were in quite an independent environment, weren't they?

She saw the fostering of exploratory and investigative skills as one of the main benefits of a visit: *'See he (John) concentrated on that for ages 'cause it's so investigative.'*

Teacher 3 – primary age group

Teacher 3 was younger again and had recently qualified.

Behaviour perceived as positive in school

Teacher 3 also saw being able to sit and listen as positive: *‘But all of them you know they’re pretty good at sitting, um taking some things in, joining in, there’s no real behaviour ...’*

Behaviour perceived as negative in school

Teacher 3 also felt that the children would do little without adult direction: *‘if it’s workwise they’d just stop or do anything (if they don’t have an adult with them).*

Methods in school

Teacher 3 remarked on the need for direction noted above but reported on a variety of activities in school:

It (sitting listening) would happen probably at least once a day but not, I would say that there was a mixture of, well there is a mixture of one to one, one to two, small group work and working as a whole class and sort of a mixture of sitting listening, doing things, practical, yeah it’s fairly equally balanced.

She remarked on the structured planning of the whole broad curriculum, *‘targets, yeah, on everything from English to toileting’*. She said that the free play sessions, an example of which was observed but not filmed, took place on Friday afternoons (field notes) and clearly made a distinction between this and work for the children.

Behaviour in the ISC

Teacher 3 spoke positively of the students' responses to the ISC, attributing them to the novelty of the trip and the children's natural curiosity:

I think they definitely did more, all of them, at the science centre, but again I think, if we do go on day trips and things you will often see them a bit more excited ...I think probably children this age are a lot more curious and to go into a situation like this, which is nothing like school ... yes it sparks off an enormous amount of curiosity.

Comments

All three teachers appeared to see the ability to sit still and listen in school or college as positive and necessary and feel that students needed a high level of direction. All expressed pleasure at the degree of independence and concentration shown by their students in the ISC and the teachers of the older group attributed this to the fact that staff stood back there. Teacher 3 felt it was more to do with the novelty of the trip. These views were explored in the explanatory phase of the research.

4.3.2 The teachers' views on the typicality or otherwise of the students' responses in the different sessions

It was important to know for the purposes of triangulation how typical, or otherwise, the teachers felt the students' responses to be in the different sessions observed. They all confirmed that the sessions filmed in school and college were fairly typical, although the teacher of the youngest group (Teacher 3) talked about a balance

between listening and practical activities during the school day and the latter were not observed apart from the free play session said to take place on Friday afternoons only.

All three teachers in the study remarked that the students' concentration in the school/college sessions filmed was, if anything, better than average, although Teacher 2 appeared to equate concentration with sitting still and quietly. Teacher 3 remarked that Michael was more responsive than usual in the first of the school sessions, motivated by the toys. The teachers confirmed that the tendency of certain students (Alan, Richard, Bill, Matthew) to wait to be told what to do in school or college was a common occurrence. All three teachers expressed pleasure at the degree of independence, problem-solving and perseverance shown by their students at the ISC and confirmed that this was out of the ordinary.

4.4 Findings Relating to Sequential Analysis

This section presents the results of the two small scale pieces of sequential analysis described in Chapter 3; the first designed to look at events leading up to sequences coded as ‘exploration’ or ‘investigation’, the second designed to analyse the effects on students’ engagement of interactions with other people.

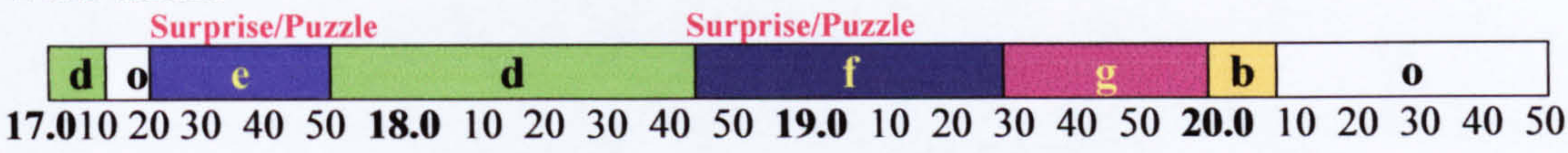
4.4.1 Sequential analysis of events preceding sequences coded as ‘investigation or exploration’

Our previous research in the ISC (Brooke and Solomon 1998) had shown how mainstream students sometimes moved from play to self-initiated investigation or exploration. Curiosity had appeared to be an important catalyst for these pupils and I was interested in looking in more detail at what preceded any instances of exploration for the participants in the present study.

Sequences were only coded as exploration or investigation (‘g’) if there was evidence of systematic variation of activity that suggested a desire to find out more. Such sequences were not frequent but occurred at some points in ISC visits for four of the five main participants (Gemma tended to set herself a goal and focus on this rather than exploring and no sections were coded as exploration/investigation). Sequential analysis was used to look in detail at what preceded these sequences at the ISC for these four participants; the first such sequences are shown in relation to the colour-coded timelines for Alan in order to show how the analysis was carried out.

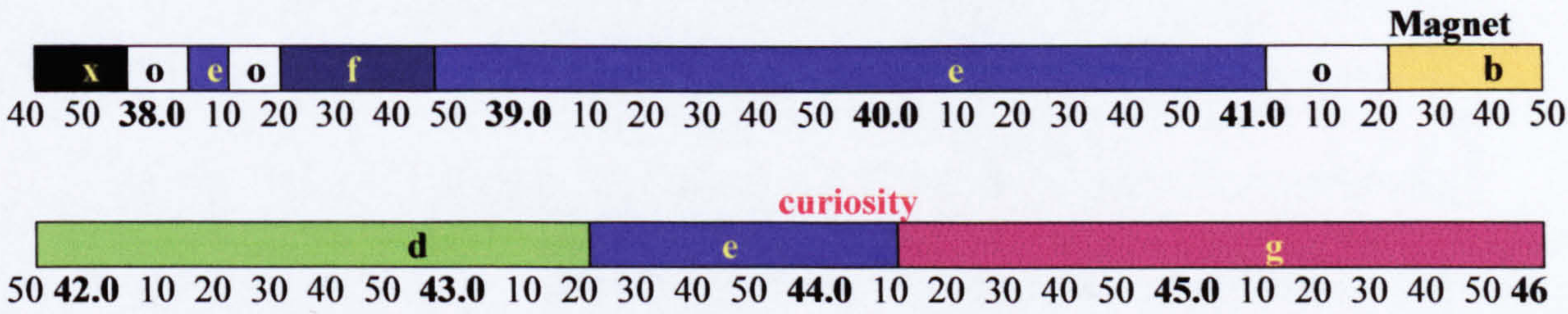
Alan: ISC 1

Wind tunnel



A very short sequence (19.30 – 20.00) was coded ‘exploration/investigation’ (g) during Alan’s first visit to the ISC when he varied the position of cars on the Wind Tunnel ramp and the way in which he released them. This was preceded by two moments when Alan had clearly been puzzled: at 17.20 he let go of a car (with a piece of card on the back) at the top of the ramp with a dramatic gesture which remained frozen when the car stayed stationary instead of rolling down the steep slope. He then tried several different cars under the guidance of an LSA (coded ‘following directions’, ‘d’). At 18.45 Alan again placed a car, this time with no roof and no card, on the ramp with another dramatic gesture and appeared equally surprised when this one *did* roll down. He tried again, without the gesture, then looked into the tunnel and repeated the same action before moving on to the brief exploration described above.

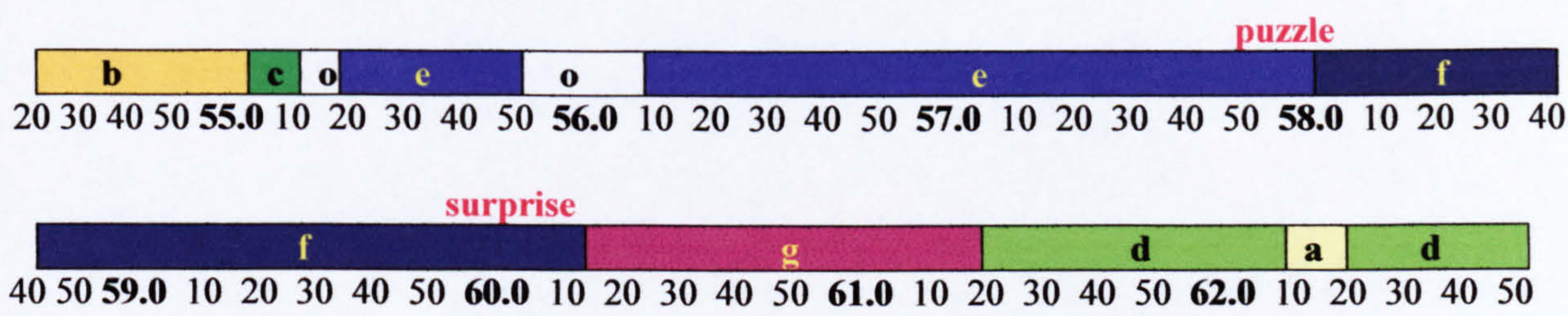
Alan - ISC 2



A slightly longer sequence (44.10 to 46.00) was coded ‘exploration/investigation’ during Alan’s second visit to the ISC when he appeared to be systematically trying different objects in the Electromagnet: he pulled on a metal spoon and an iron bar,

then took both out very deliberately, picked up a plastic spoon and put it back on the table, apparently rejecting it. After this he selected the force meter, looked at it closely, placed it and the bar in the magnet, reached towards the switch without touching it, then picked up the instruction/suggestion card and looked at it closely for some time before asking H1 about it. This sequence also appeared to have been preceded by an element of curiosity: at 43.20 he had placed an iron bar in one end of the Electromagnet and a metal spoon in the other with the magnet switched off. When he switched on both the spoon and the bar were pulled right in, Alan took the spoon and pulled and pushed it then looked into the magnet. This was followed by the sequence coded ‘exploration’.

Wind Tunnel



From 60.10 to 61.20 in the same visit one more short sequence was coded as ‘exploration/investigation’. Again Alan was at the Wind Tunnel: he very slowly placed a car at the top of the ramp, held it against the wind with his finger for over a second then let go, the car stayed where it was, he pushed it gently down into the wind, it returned to its previous position. Alan smiled and shrugged then pushed it down again a little harder. When asked why the car stayed up he smiled but did not reply, although he went on to show with a gesture that he knew exactly what would happen if the wind was turned off. This sequence is immediately preceded by the car having been blown backwards off the ramp and a little earlier (57.50) by a moment

when a car had moved gently up and down the ramp of its own accord and again Alan had appeared puzzled.

Karen - ISC 2

Two short sequences at the Motion Detector (30.40 – 30.55, 31.20 – 31.45) are coded as ‘exploration/investigation’ during Karen’s second visit to the ISC. In the first Karen was hopping backwards and forwards, varying what she was doing and watching the screen, then, having re-set the equipment, she tried hopping again, then running back and forth, but then stopped near the screen watching (remaining immobile makes a straight horizontal line on the time/distance graph, something most of the primary-age mainstream pupils found confusing). When the line reached the end of the graph Karen exclaimed, ‘Yes!’ with a triumphant gesture suggesting she had achieved an aim or found something out. This was not observed at the time, it would have been very interesting to know if she could have repeated it. No obvious puzzle or curiosity preceded this sequence; Karen had been moving faster and slower in front of the screen, building towards what seemed like a deliberate exploration of the possibilities of the equipment (‘what happens if I do this...?’), rather than an investigation of cause and effect (‘why does this happen?’). Her response to the straight line is more puzzling; if she had noticed this before it was not captured on video.

Two more short sequences at the Electromagnet were coded ‘exploration/investigation’ during this visit. From 38.10 to 38.50 Karen carried out a small investigation with a metal spoon and iron bars. Just before this she had appeared puzzled when an iron bar that she had just used to pull another bar out of the

magnet appeared incapable of pulling out a metal spoon, presumably because the pull of the magnet was stronger. Karen took the spoon out with her hand and looked at it and into the magnet, apparently puzzled. She then moved on to her brief investigation, first repeating the same sequence of actions as before with the same result, then carefully placing the iron bars end to end and pulling sharply; the spoon almost followed but was pulled back into the magnet at the last moment. Getting the spoon out with the bar then appeared to become a goal and the next sequence is coded as problem-solving, 'making adjustments to achieve a goal' ('f'), rather than investigating ('g').

From 39.25 – 42.10 a further sequence at the Electromagnet was coded 'exploration/investigation'. This sequence also started with a puzzle: Karen had placed a piece of lead in the magnet and nothing had happened. She tried to pull it out with the iron bars and when these simply pulled each other out she looked at the lead and moved it around a little, apparently surprised that what appeared to be a metal was not behaving as she expected. She went on to try aluminium, discarded that when it too was not attracted, picked up the plastic spoon but rejected that without trying it, then tried a range of other objects in a variety of ways.

Bill - ISC 1

On Bill's first visit to the ISC a very short sequence (27.40 – 28.10) at the Wind Generator was coded as 'exploration/investigation': Bill picked up a piece of card from the floor and held it in the air stream. It was blown out of his hands, he picked it up, held it in the wind again, carefully changing the way he did this, watching what was happening. There was no particular build up to this; Bill had just come

over to the apparatus, but he seemed to be exploring its possibilities beyond what had been demonstrated in the introduction to the session. Two short sequences at the Circuits were also coded as 'exploration' for Bill: he moved the wires around so he had plugged the spinner in by a light and vice versa (36.45-37.35), then moved away for a few minutes and when he returned (42.00) he bent over the still turning spinner. One lead was still plugged into a different socket, Bill unplugged it, plugged it in again, watching closely, looked carefully at the sockets, unplugged the spinner, plugged in the light, looked closely again and plugged in the second light. Again there was no obvious moment of surprise or puzzlement preceding these sequences, although he may have been intrigued by the fact the leads could be moved to sockets next to other pieces of equipment and still work for the original piece.

Bill - ISC 2

On Bill's second visit a slightly longer sequence was coded 'exploration' (36.30-38.35) at the Wind Tunnel; his exploration there was a variation on what he had done with the Wind Generator on his first visit but more prolonged. He held a piece of card in the wind and released it several times, then placed the card so the wind was holding it against his hand, turned to H1, keeping it like this, and smiling, before moving his hand so the card blew away. He retrieved it, held it in the wind and released it several more times, varying the position in which he held it and at one point holding it right down inside the wind tunnel before releasing it. Again this did not seem to stem from a particular puzzle, he had moved on from using cars in

the tunnel to using the card, gradually increasing variations in what he was doing, exploring the possibilities of the equipment.

Michael - ISC 1

Michael's activities at the Wind Tunnel were coded as 'exploration' throughout the part of the time that he spent there that was filmed (34.35 – 39.40); he was off-camera before that so it is not possible to say what preceded the sequence. He had never used the Wind Tunnel before and seemed keen to explore all its possibilities; he put his face in the wind, jumping back and squealing with pleasure, then moved back towards the tunnel, turned so the wind was on his back, turned again so his face was in the wind. He reached in for a car, placed it on the ramp, then pulled a foam ball out of the tunnel and tried to throw it back in. He approached the tunnel again with his back to it, carefully lowered his bottom onto the ramp then jumped away again, squealing. He carried on exploring the possibilities of the Wind Tunnel for five minutes, with his body, with cars, foam balls and pieces of card, even at one point lifting a fellow-student so her skirt was in the wind.

A second sequence at the Wind Tunnel (51.45 – 53.05) was also coded 'exploration': Michael went over to the Wind Tunnel, picked a piece of card up off the floor, placed it on the ramp and let go; the card flew up in the air and Michael retrieved it. He placed the card on his head and let go. Having retrieved it again, he put the card right down inside the tunnel, screwing his eyes up against the wind and let go so it flew out. The next time he placed it on the ramp, and held it down with both hands before letting go; the card blew onto his stomach and was held there by the wind, causing Michael to shriek with laughter. He continued to vary what he was doing, watching

intently until 53.05, again seeming to be exploring the possibilities of the equipment. No sequences were coded as exploration for Michael during his second visit when he seemed to be in a very different frame of mind.

Comments

The short sequences described above suggested two different types of exploration: one relating to a surprise or a puzzle, leading to investigation designed to find out about cause and effect (why did that happen?) the other simply an exploration of the possibilities of the equipment (what happens if ..?).

4.4.2 Sequential analysis designed to explore the effect of interactions with other people on students' engagement with activities

Interactions with other people emerged increasingly as having a significant influence on students' engagement levels but not necessarily in positive way. All interactions with other people during ISC visits were mapped onto the colour-coded timelines for the five main participants to make it possible to look at changes in behaviour during or following these. It had originally been hypothesized, following observation, that the participants' engagement levels and motivation were increased by non-verbal scaffolding, decreased by verbal intervention. As sequential analysis was carried out, however, no straightforward link emerged to support this but it appeared rather that locus of control was an important factor in engagement levels. Interactions were re-coded both according to whether they were verbal or non-verbal and whether the student remained in control or whether the other person took control. This was carried

out for the five main participants for all ISC visits. As before this has been set out in detail here for the first visit for one student to show how this was done; for the other visits for this student, and for the four other students, interactions are marked on the colour-coded charts of visits (Appendix VI) and have been described in accounts of visits, so are only summarised here.

Key to interactions:

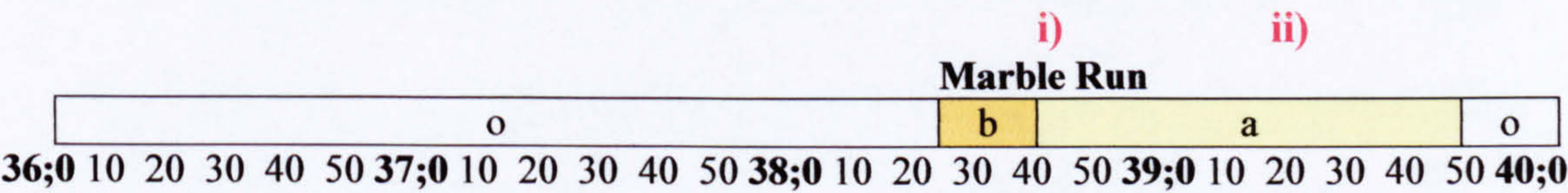
i) verbal input, other takes control

ii) non-verbal input, other takes control

iii) verbal input, student maintains control

iv) non-verbal input , student maintains control

Gemma ISC 1



Gemma was at the Marble Run and clearly interested but her teacher was keen for her to experience other things and asked her if she wanted to see the Breathing Skeleton (38.40). Gemma didn't move and resisted the teacher's attempts to take her arm, although she did eventually follow (39.50). The teacher had taken control through verbal and then non-verbal input and Gemma's involvement had diminished.

Breathing skeleton																										
										i)		i) + ii)														
o										a/b		o		a												
40;0	10	20	30	40	50	41;0	10	20	30	40	50	42;0	10	20	30	40	50	43;0	10	20	30	40	50	44;0		

Once at the skeleton Gemma's teacher attempted to use it to explain verbally what was happening and how we breathe; Gemma looked at the ceiling and then at the skeleton but did not respond. The teacher demonstrated blowing up a plastic bag (subsidiary activity with the skeleton) then put it to Gemma's mouth, directing her to *'take a deep breath, take a deep breath. One, two, three.'* And when Gemma didn't respond, said, *'I'm sure you can do it. Blow, come on ... and blow. Good girl.'* Again the teacher had taken control and Gemma showed very little interest.

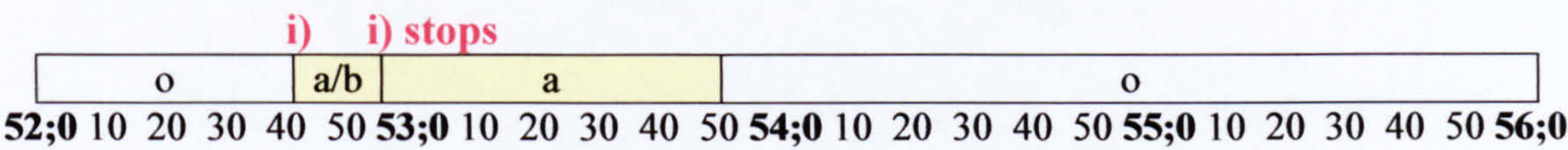
										Circuits														
i)					i) + ii)										i)									
															ignored									
a		o (d)			a		o										b		a	e				
44;0	10	20	30	40	50	45;0	10	20	30	40	50	46;0	10	20	30	40	50	47;0	10	20	30	40	50	48;0

Gemma was briefly off-camera (44.15- 44.45) but the teacher could be heard saying *'there you are, blow, that's better, good ...'* and when the camera was on them again thirty seconds later the teacher was holding the bag to Gemma's mouth and saying *'there, like blowing up a balloon, like at a party. Have another go.'* Gemma averted her head and then shook it, ducked under the teacher's arm and walked away off-camera (45.10).

										iii)		iii) + iv)													
												e								x		o		x (a/b)	
48;0	10	20	30	40	50	49;0	10	20	30	40	50	50;0	10	20	30	40	50	51;0	10	20	30	40	50	52;0	

At 47.50 Gemma moved of her own accord to the Circuits. Her teacher called, *'Gemma!'* (48.00) but Gemma ignored her and squatted by the table, immediately seeming very focused on what she was doing, slowly and carefully connecting the circuit to make the spinner turn. Staff exclaimed at what she achieved or came up beside her to demonstrate other possibilities but all were ignored and Gemma worked

with concentration and a clear goal for over four minutes (47.50 – 51.20). At this point a helper went over and tried to engage Gemma’s interest in the electricity meter, explaining its function verbally. Gemma stopped what she was doing and watched.



Her response was hidden at first (51.20-52.40) but when it could be seen again (52.40) her body language (kneeling low, away from the table) suggested lack of interest. At 52.55 the helper was called away and Gemma knelt up again, disconnected the circuit and looked around the room, having apparently lost interest.

Gemma - ISC 2

Gemma appeared much more confident on her second visit to the ISC, tending to direct others, rather than allow herself to be directed, retaining control in any interactions with Richard and Alan throughout the session; she was fully engaged for the great majority of the time that she was on-camera. She appeared to enjoy having a staff audience for what she was doing (11.30) and clearly enjoyed working collaboratively with Richard on her own terms (11.40-13.45, 20.05-21.10). Her engagement level was reduced when her teacher insisted on Richard being allowed to use the fixed dominoes on his own (13.45) but when she had made something with the other set of dominoes she waited for her teacher’s attention and instruction before demonstrating it (16.45).

Gemma - ISC 3

On Gemma’s third visit only she, Richard and Alan were present and she directed the other two from the start, giving them step by step instructions, always remaining very

involved herself in what was happening. At the Giant Dominoes she ignored a question (0.30) from a helper and then a suggestion about how to place the board with the fixed dominoes (1.20) but accepted the same suggestion from Richard (1.50), quickly going back to telling him and Alan what to do however (2.20). She rejected independent attempts to help from Richard (2.20) and Alan (2.55) that didn't fit in with what she was doing. All three moved on to the Pulleys (6.30) at Gemma's instigation and she continued to maintain control, directing the others, rejecting their attempts to move from her agenda. When Alan moved away (14.30), Gemma called him back, and, when this was ignored, wanted to follow but was persuaded not to by H1 (15.0) and moved off-camera with Richard. She had maintained control and a high level of engagement throughout the time at the Pulleys ((6.30-15.0) until H1 intervened to allow Alan the chance to do something on his own.

At the Motion Detector (18.30), she allowed H1 to show her how to set it going (18.45-20.15) and was then able to do this independently; accepting the help she needed had maintained her engagement level. She returned to directing Richard once H1 had moved away, telling him not to move in front of the beam, although this was the point of the activity. After five minutes (25.30) she appeared to lose interest in this activity and, finding a pencil, proceeded to instruct Richard in writing his name until 29.20, not the intended activity but certainly one that absorbed her.

For the rest of the session she continued to direct Richard, briefly consulting him at one point about whether to lower the bucket with the pulley rope (40.30) but carrying out the action before he had a chance to reply. Again she accepted help where this was clearly needed, for example to re-thread the pulley ropes (40.10). Richard generally seemed happy to accept Gemma's direction and her engagement levels

remained high as long as she was in charge. She lost interest slightly when Richard was trying to show her how to hit the Thump Wave drum more effectively and moved away (45.40). Richard began to show signs of restlessness when being measured by Gemma for the second time and H1 suggested he move to a different activity, distracting Gemma from following by asking her about what she had been doing. Gemma did not respond and in taking control in order to give another student a chance to do something else H1 appeared to have reduced Gemma's engagement level (53.10).

Alan - ISC 1

From Alan's first visit to the ISC he was much more engaged with activities when left to do things on his own. From 17.05 to 19.55 he was at the Wind Tunnel, an LSA was beside him but initially standing back, Alan was clearly very involved in what he was doing. The LSA briefly directed him and he followed the directions with some interest (17.50-18.40) but once left on his own went on to make adaptations to what he was doing (18.40-19.30) and then to the short piece of systematic investigation (19.30-19.55) described above. From 34.15 to 34.40 Alan followed Sam's directions at the Tilting Gutter, then Sam handed him the ball and moved away. Alan spent a few seconds throwing it in the air then proceeded to use the Tilting Gutter independently with a degree of interest and concentration he had not shown at any point up to then at the ISC or during the college session (34.55-41.40).

Alan - ISC 2

On Alan's second visit to the ISC, when he, Gemma and Richard were the only students present, Gemma was very much in charge to begin with, first at the Giant

Dominoes (0-6.15) then the Pulleys (7.15-15.0). Any attempts by Alan to do something independently were quickly rebuffed by Gemma and occasionally by Richard (1.55, 5.30). Alan followed Gemma's rather patronising-sounding directions but stood head down or looking around the room when not actually being told what to do, in much the same way as he had done in the greenhouse at college. It was not until a helper from the ISC encouraged him to move to the Tilting Gutter on his own (15.0) (and discouraged Gemma from following) that he really began to do things independently and then he did so with as much interest and application as on his previous visit 15.55-29.0). Later (41.45) he was seated at the Electromagnet and very politely asked the helper for assistance. When this had been given, both verbally and with demonstration, Alan went on to explore the possibilities of the magnet as described above. Alan's response to help that he had requested was very different to his response to being told what to do. On both ISC visits Alan's whole demeanour appeared transformed when he was allowed to be independent.

Karen - ISC 1 (Preliminary study)

From Karen's first visit she was interested and keen to do things independently. She accepted minimal verbal or non-verbal suggestions from staff (a helper adjusting the tube on Water-Lift (31.35) or asking her if she can make the cups turn the other way so they pick up the water (32.00)). She also accepted help when she needed it, for example for refilling the water reservoir on the Water-Lift (33.10). A little later (33.35) a helper wordlessly adjusted the tube on the Water-Lift so the water ran onto the water-wheel, then adjusted the little bucket so it was lifted by the wheel and Karen went on to make this sort of adjustment herself. She rejected attempts by fellow-students to join or help her in activities, for example brushing another

student's hand off the Water-Lift (32.10) when she was using it. She appeared to enjoy interactions where she was in charge, however, such as blowing wind from the Wind Generator into her teacher or fellow-students' faces (48.20).

Karen - ISC 2

Again Karen was again interested throughout her second visit and determined to be independent. She accepted help such as re-threading the pulley ropes (10.0) and someone retrieving the ball for her (11.50) but moved away from an LSA's attempt to demonstrate how the Wind Tunnel worked (14.30-14.50). She had been watching the LSA and another student there for a few moments but when the LSA started to demonstrate and told her to watch, she said, '*No, no*' and walked away. She spent a short time at another piece of equipment but as soon as the Wind Tunnel was free she got up and went directly to it, then spent over six minutes (17.55-24.00) working there alone with great concentration and perseverance. The only point at which she was momentarily less engaged was when a helper asked her with word and gesture about what she was doing (19.35).

Karen later accepted help with setting the Motion Detector (27.20) until she could do it herself then called to her teacher to watch (30.0) as she explored its possibilities. She ignored a question from her teacher about whether she was sharing (37.20) and fellow students were also mainly ignored although she reset the Motion Detector for one (42.55) and briefly collaborated with another at the Pulleys (54.0 – 55.40) while remaining firmly in charge.

Karen - ISC 3

On her third visit Karen again accepted remarks or suggestions that helped her in what she had decided to do - for example a reminder that the rope she had been using at the Pulleys to raise the bucket was the one designed to tip it (1.20) - and requested help when she needed it, for instance to re-set the Motion Detector (9.10). She ignored questions, such as whether she remembered how the magnet worked (6.30) but accepted being shown how to turn it on (6.45). She asked Bill with sign and gesture whether she could join him at the Tilting Gutter (7.40); they worked together for a little over a minute, control shared, and invented a little game, using the gutter to roll the ball back and forth between them. Interventions from staff – a reminder from her teacher to share when she was already doing so (7.50), and questions from a helper designed to encourage her to think about adjusting the position of the bucket (8.0, 8.40) - were ignored. She collaborated with fellow-students on a number of other occasions, helping Jackie at the Thump Wave (11.0) and allowing another student to help her at the Wind Tunnel (12.35), but she remained in control. She also collaborated with a helper at the Giant Dominoes and again at the Pulleys (37.40-42.35) but each time Karen remained in charge, giving instructions, deciding on turns, asking for help when she needed it.

Karen showed a strong desire to be independent and very high engagement levels when allowed to be so on all her visits to the ISC. She asked for or accepted help when she needed it but usually ignored or rejected attempts to direct, instruct or question her. From her second visit she appeared happy to collaborate with fellow-students or staff as long as she was in charge or control was shared.

Bill – ISC 1 (Preliminary study)

On his first visit to the ISC Bill frequently avoided attempts by staff to help or demonstrate, but left to himself he showed high motivation (although he had been said to be difficult to motivate) and good understanding, for example of the circuits and interest in exploring these. He walked away from attempts by a helper to show him what to do with the circuits (12.10) and later (43.45) had been trying out different combinations with the circuits, when a helper again came over and began to demonstrate; Bill watched for a few seconds then moved away. He tried to avoid letting other students take a turn (19.40) or simply ignored them, for example going over to the circuits when Jackie was using them (36.20), leaning across her and beginning to use them himself. Other students tended to avoid him, particularly John who moved away when Bill approached on several occasions (27.35, 28.25, 39.05); the teacher had said that the others were scared of Bill and this did seem to be the case during this visit. At one point the teacher intervened (28.35) to ensure that he allowed others their turn, reducing his engagement but protecting the rights of others.

Bill - ISC 2

Bill began his second visit by operating the Tilting Gutter on his own with a member of staff rolling the ball back to him but quickly made way for another student, Martin (2.25). Martin was in a wheelchair and Bill adjusted the position of the bucket for him then tilted the gutter to make it easier for Martin to place the ball on it. They collaborated until 4.00 when Martin moved away, control mainly shared although Bill took slightly more, deciding on turns. Bill was then joined by Karen (5.25) and they invented the little game described above from Karen's point of view (6.15 – 6.35). Bill ignored a question from a helper designed to get him to think about how to adjust

the bucket (6.35) but responded well to his teacher when she asked him (with signing), '*What do I have to do?*' (7.0), leaving Bill in charge. They worked to a shared goal, the teacher encouraging (but not directing) Bill to make adjustments. At 10.25 the teacher went away and Bill continued to work with concentration ignoring further non-verbal and verbal attempts to get him to think about which way to move the bucket (15.40, 17.15, 17.50). At 29.05 he was at the Motion Detector with an LSA, moving towards the sensor, watching the screen and smiling. The LSA asked, '*Shall we do it again?*', again leaving Bill in control; when he agreed she re-set the apparatus and Bill moved, increasingly varying what he was doing, intently watching the effect this produced. He ignored a question about what he thought made the Thump Wave clown move (31.25) but responded to a silent offer of card and sellotape when he was using cars in the Wind Tunnel (35.45). At 42.30 Bill was at the Electromagnet with John. They jointly developed a game (Bill slightly dominant but only slightly) pulling metal objects back and forth between them through the magnet, each using an iron bar at their end to pull on something that is inside, both laughing. This continued until 52.30 when an LSA suggested trying other objects and a helper offered a plastic spoon to try. Bill and John complied with staff suggestions (52.45) but these had the effect of making their game less inventive and they soon returned to their original activity. Other staff interventions - to ask if they are alright (57.40) or want to go to the toilet (57.55) - were ignored or retained their attention for less than five seconds. A question about what was happening (i.e. with the magnet) (60.05) was also ignored as was an (unnecessary) instruction from the teacher to Bill to share (60.15) and a question about whether they were hungry (62.50). The LSA also told Bill to share (60.45) and began to help John, with the result that the game became more competitive, although there was still no real friction between the students.

Bill was again engaged from the start on this second visit and on this occasion appeared much more responsive to both staff and students. He ignored staff attempts to question him or move on what he was doing but accepted help and collaboration. He and John collaborated with clear enjoyment for over twenty minutes in contrast to the previous year when John avoided him. Their teacher said that such collaboration between them was still unusual at that time, however.

Michael - ISC1

From 27.10 to 30.30 Michael was using the Pulleys; non-verbal scaffolding from staff – help to sort out pulley ropes or having the ball returned to him - kept him interested. Later he was playing with the skeleton (30.40 – 31.00), but was called away by an LSA when he tried to climb on the bike alongside it. This intervention reduced Michael's engagement but was doubtless seen as necessary to protect equipment. Michael went on to explore the possibilities of the Wind Tunnel (34.35 – 39.40), as described above; his teacher joining in briefly appeared to enhance Michael's involvement. He also showed a desire for an audience, at one point calling, '*Watch!*'; and continuing when an adult replied, '*Yes, I'm watching, go on then!*' At 39.40 an LSA brought over another pupil, who was in a wheelchair, and held her hand out to Michael for the card he had been using; Michael moved away, his exploration brought to an end by the LSA's wish to give another student a turn. Later (45.20) Michael went over to where water and straws had been provided by the fish tank for the students to make 'fins' and try the feel of them in the water. He put a handful of straws in the water but was stopped from doing this by an LSA and wandered away again.

Collaboration enhanced Michael's involvement during this visit, particularly when his teacher joined in his exploration, others taking control - for reasons that they might well have considered necessary, to protect equipment or make sure another student had a turn – caused it to diminish.

Michael - ISC2

Early on during his second visit (7.15) Michael was playing with a bucket at the Pulleys and put it on his head; an LSA tapped on it and gestured to him to take it off. He appeared less keen to explore than on his previous visit, frequently picking up string or tape and twirling it, putting his head down on a convenient table, his thumb in his mouth and shutting his eyes. Staff frequently stopped him from doing this - his 'statement' had noted that he needed 'to be discouraged from twiddling objects with his hands as this interfered with his learning'. His teacher had also remarked on the need to discourage this 'because it was such a distraction' (see pen-portrait) and another member of the school staff remarked that they found it hard to stand back at the ISC because they wanted the children to do their best there (field notes). On various occasions attempts to interest Michael in the activities by demonstration were ignored (10.05, 13.15, 24.20) or avoided (17.25). Attempts to remove the string by another pupil (23.30, 29.00) or to persuade him to relinquish it by staff (24.50, 29.05) were resisted. He was more involved again in the subsequent follow-up session so may simply have been tired; attempts to prevent him 'twiddling' were in any case ineffective.

4.5 Summary of Findings

4.5.1 Bar graphs showing proportion of time spent in different types of engagement

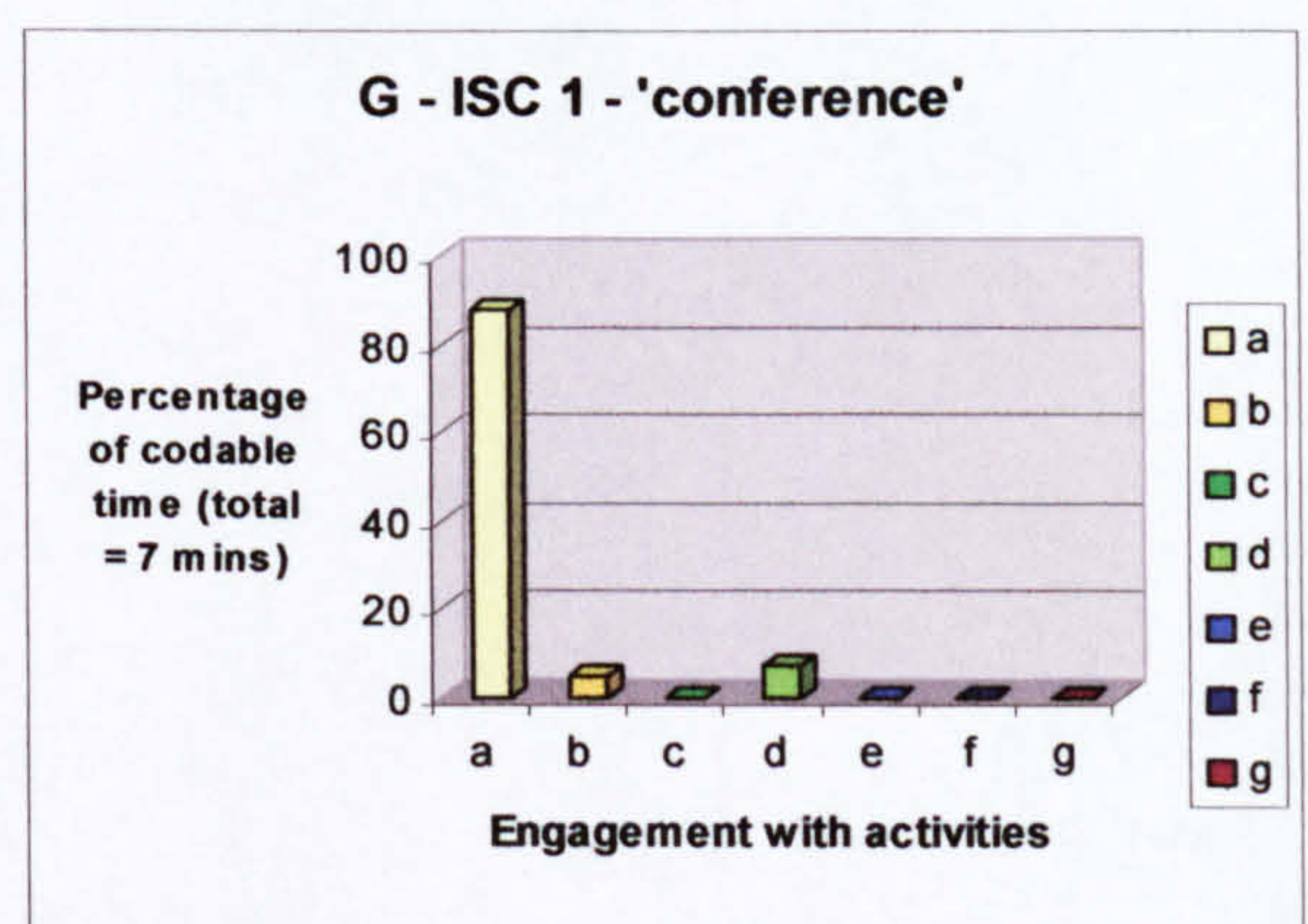
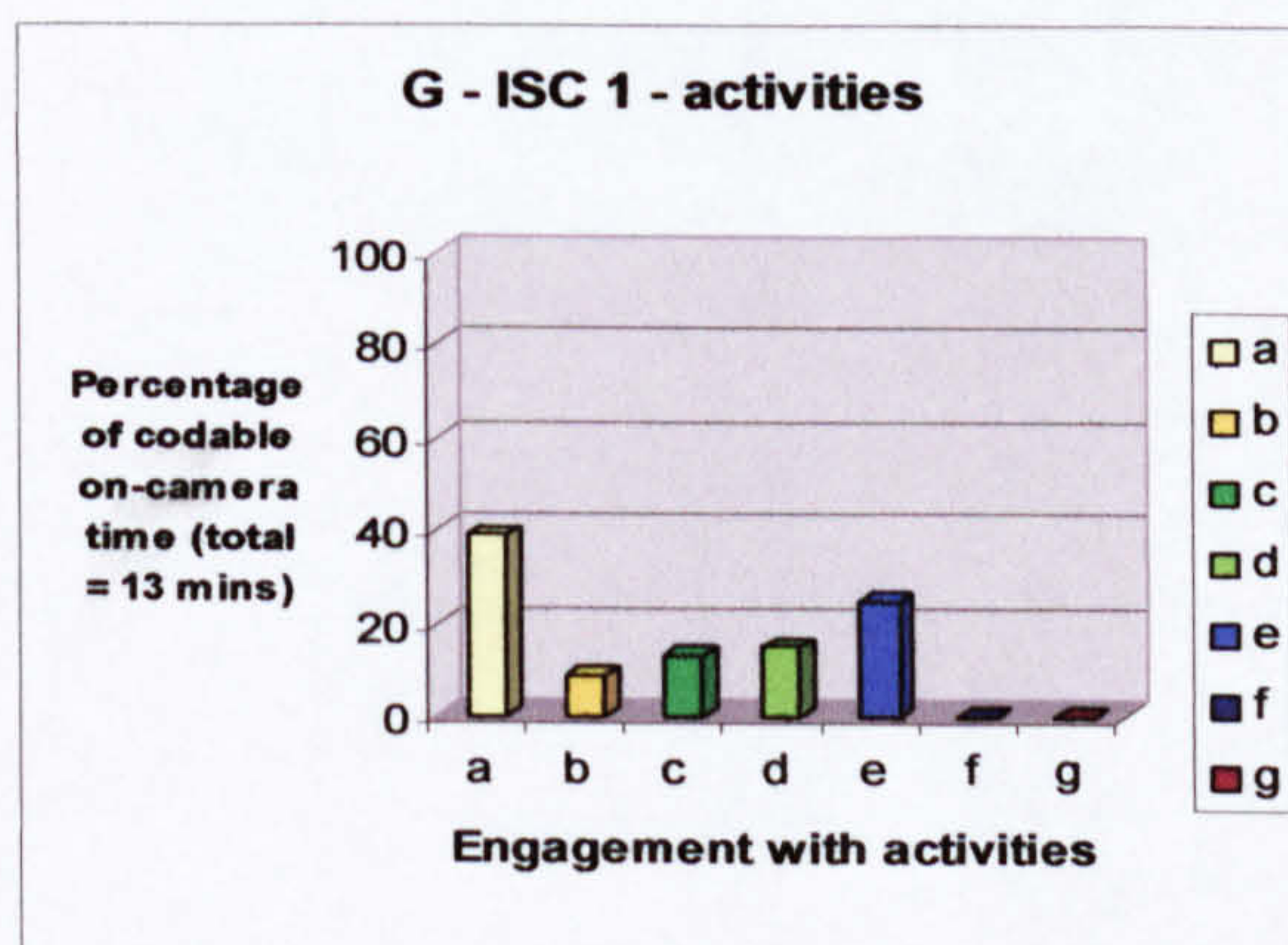
The percentage of time spent in each level and type of engagement was calculated for each of the five main participants for all sessions: ISC visits, follow-up sessions and school or college sessions. Percentages were calculated separately for demonstration, activity and 'conference' sections of ISC visits and also for discussion and activity sections of follow-up sessions. The findings are presented as bar-graphs and, with the colour-coded charts (Appendix V), provide a visual summary of findings.

Key:

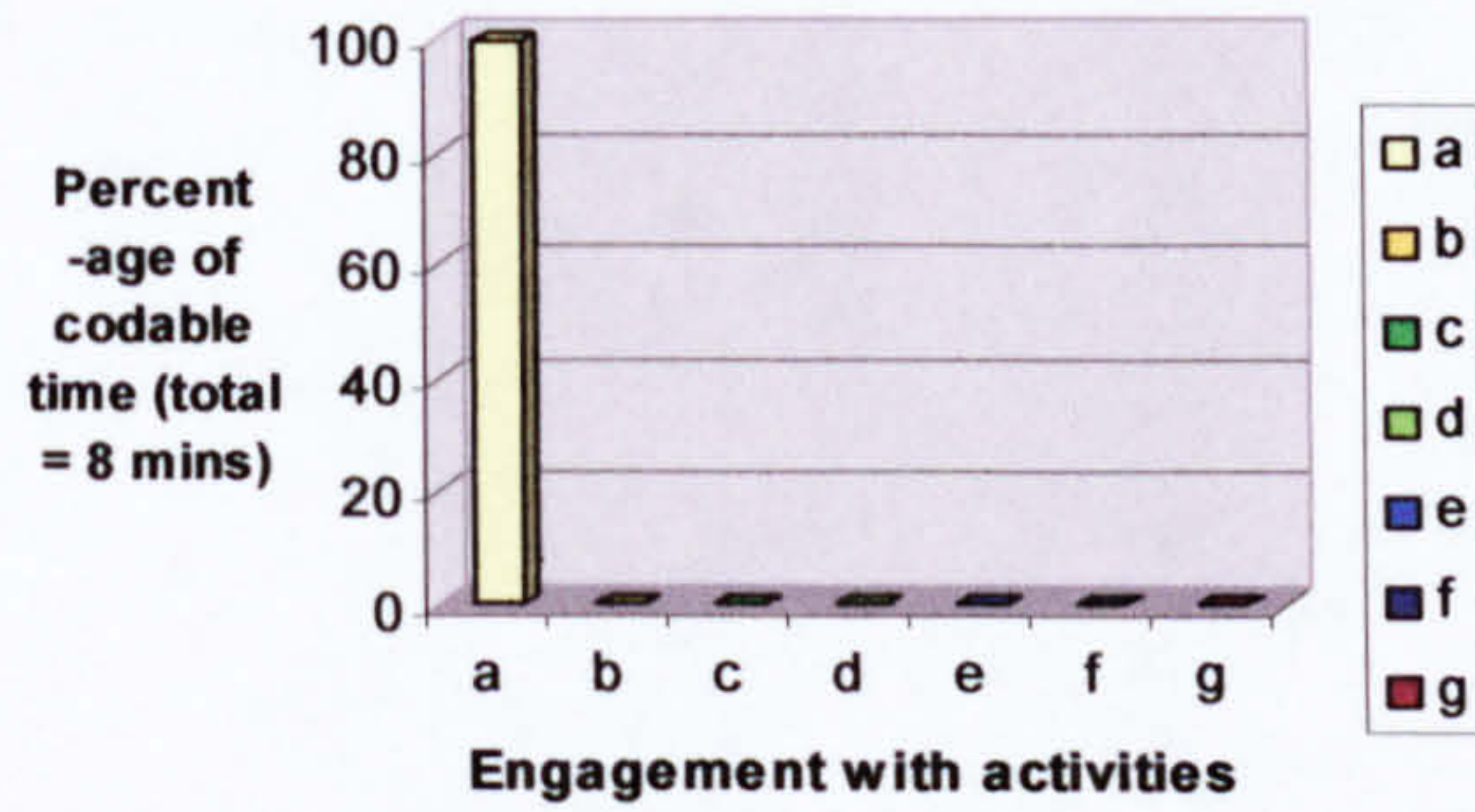
a	b	c	d	e	f	g
Not focused on activity	Initial interest	Playing/trying out	Following instructions	Working to goal	Making adjustments	Investigation/exploration

x	o
Uncodable	Off camera

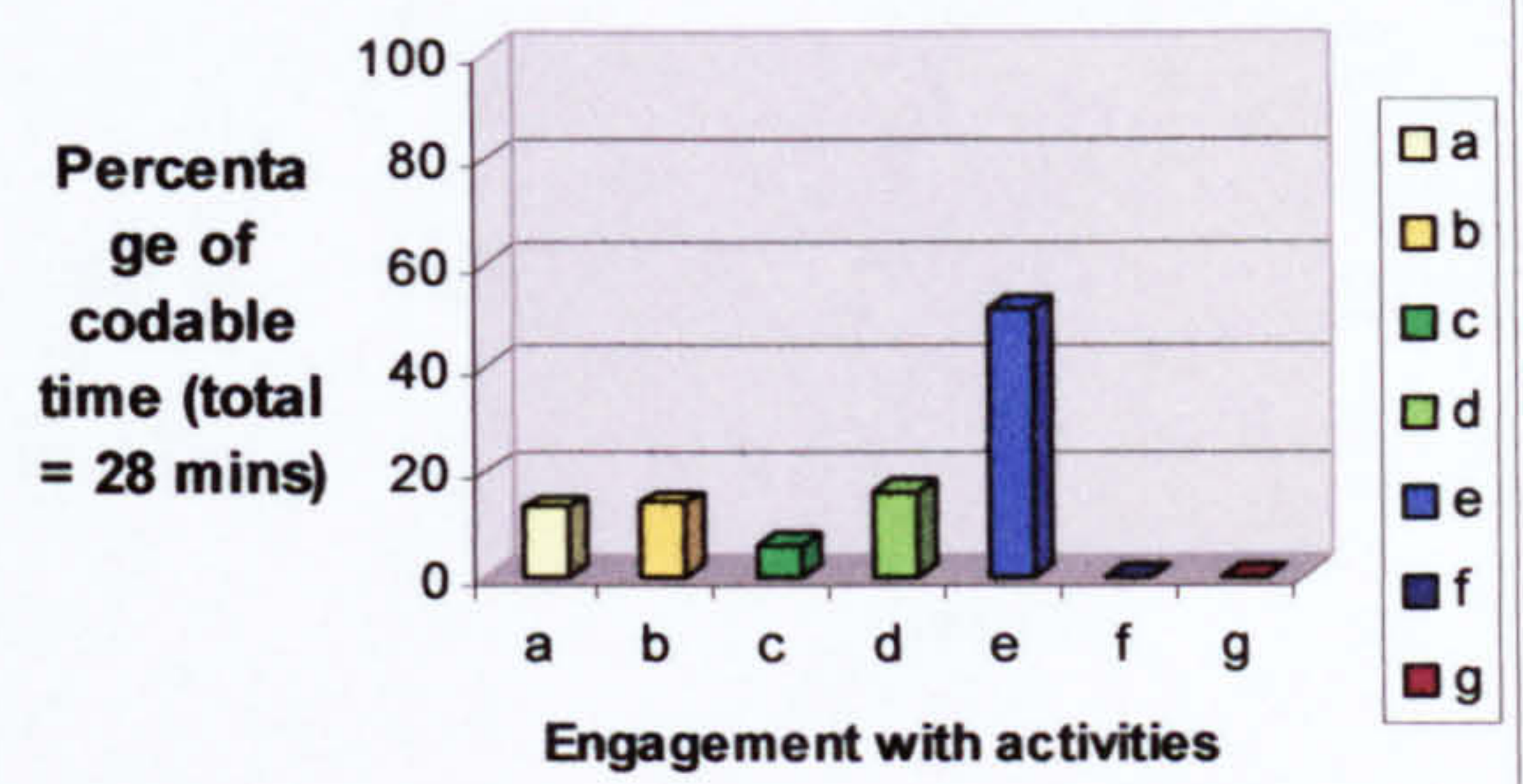
Gemma



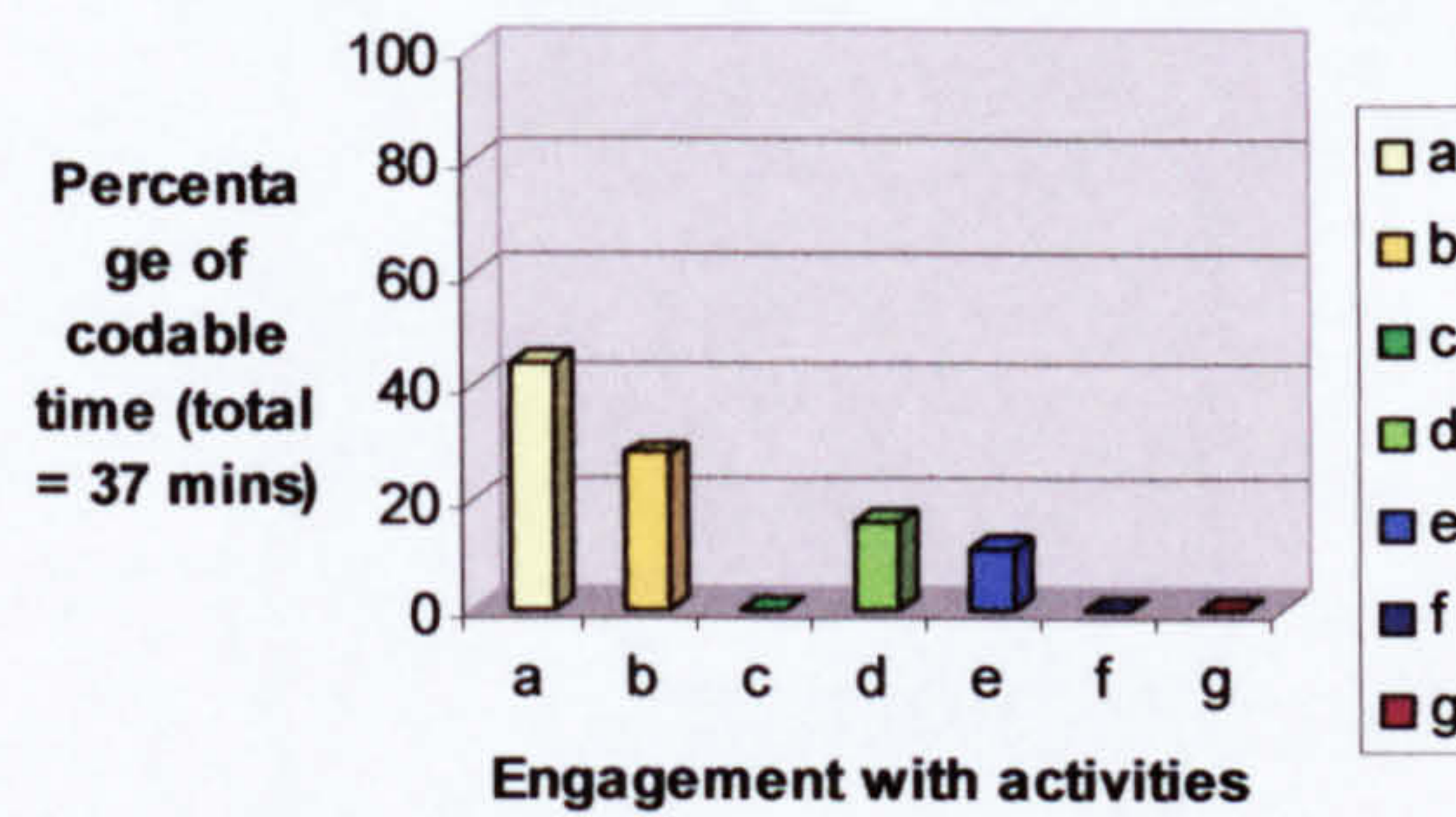
G - Follow-up 1 - discussion



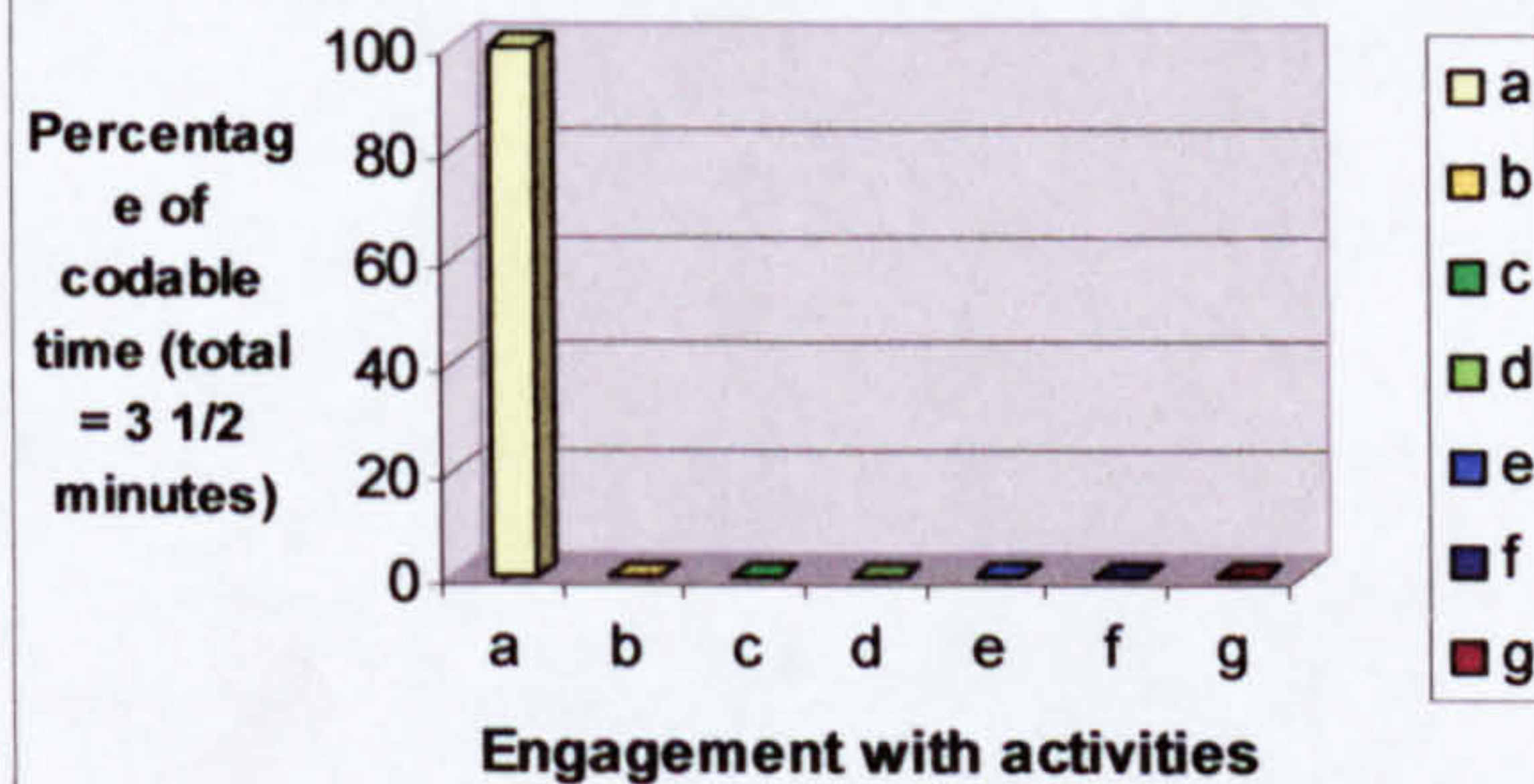
G - follow-up 1 - activities



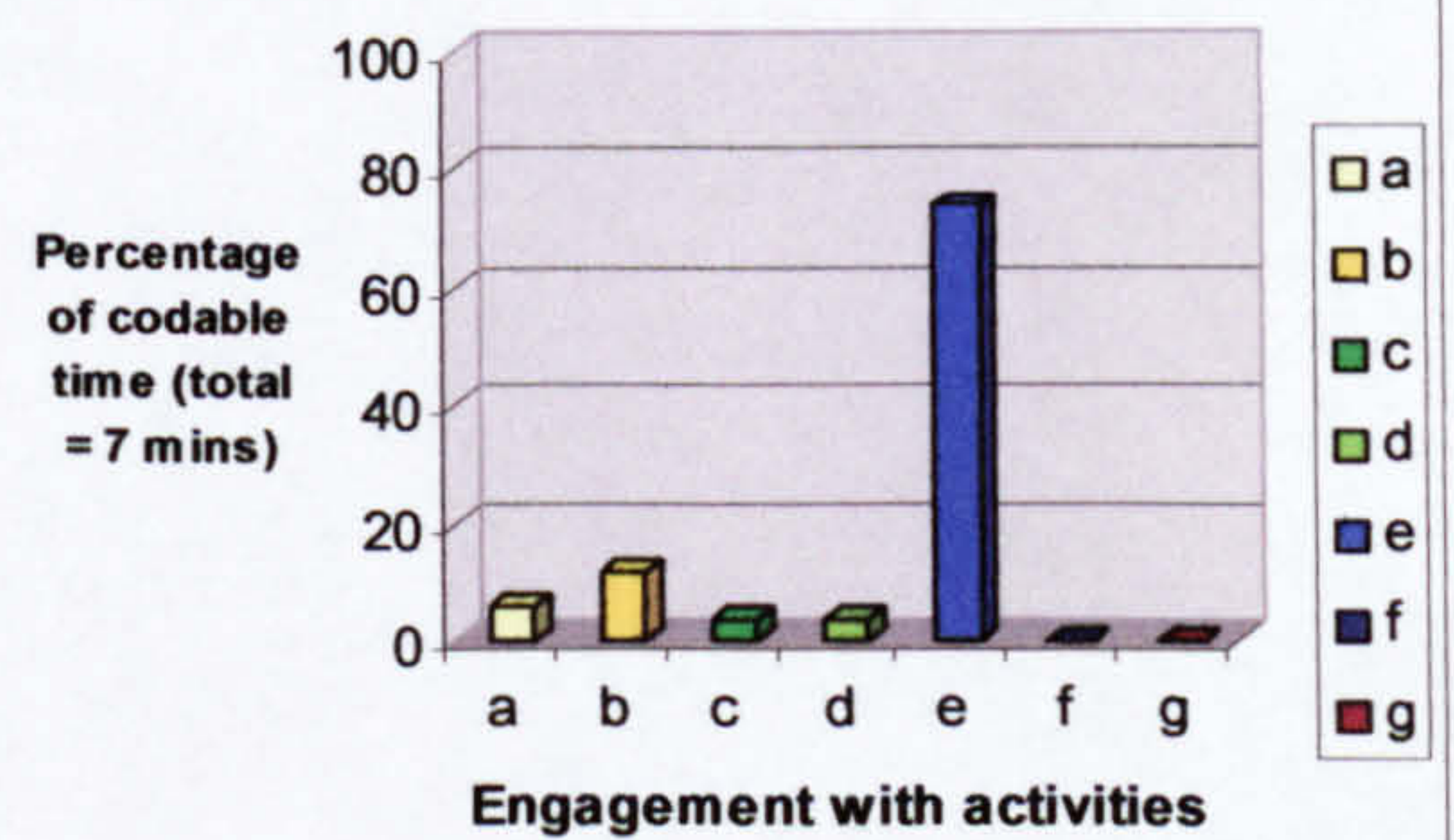
G - college 1



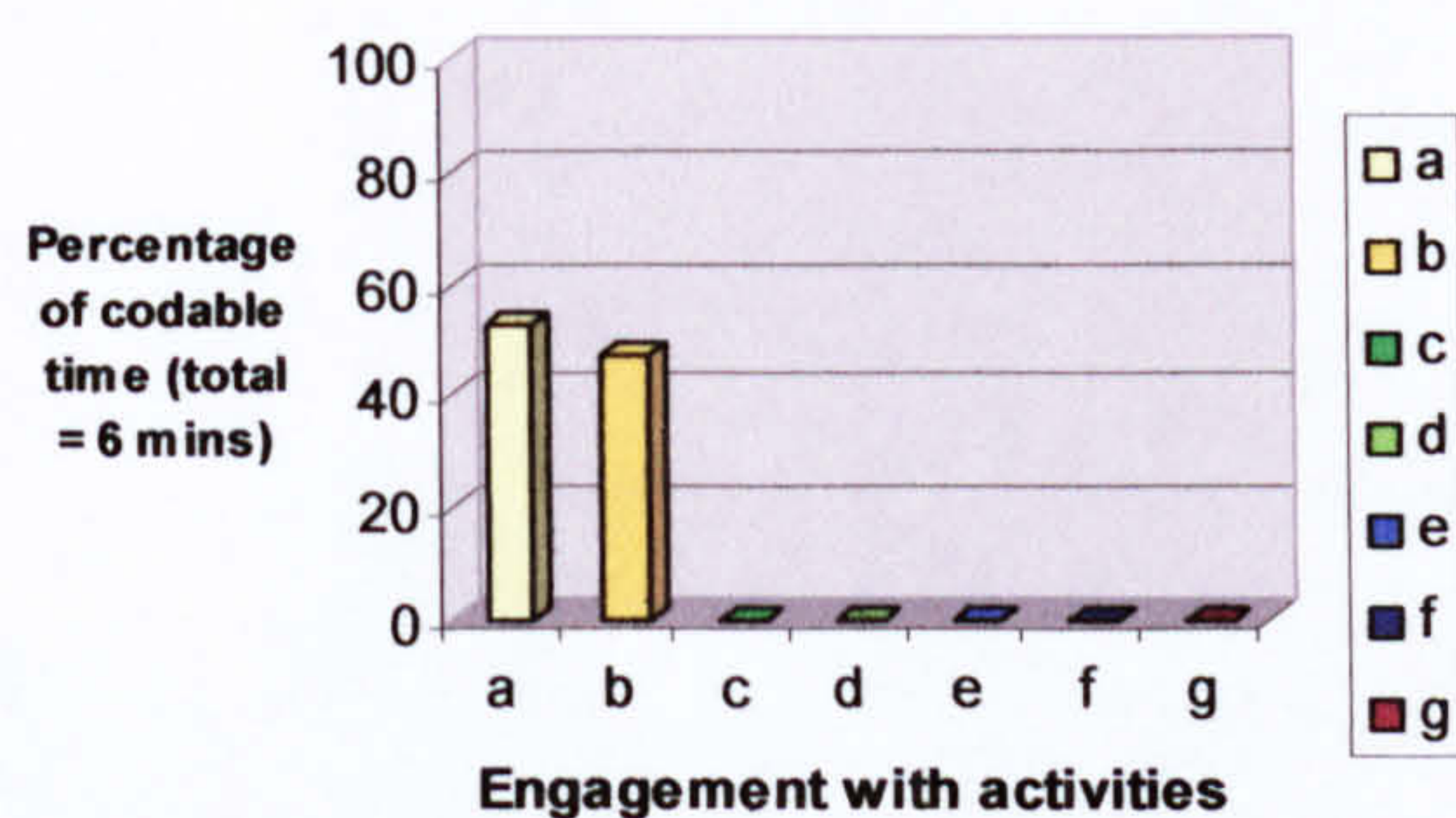
G- ISC 2 - demonstration



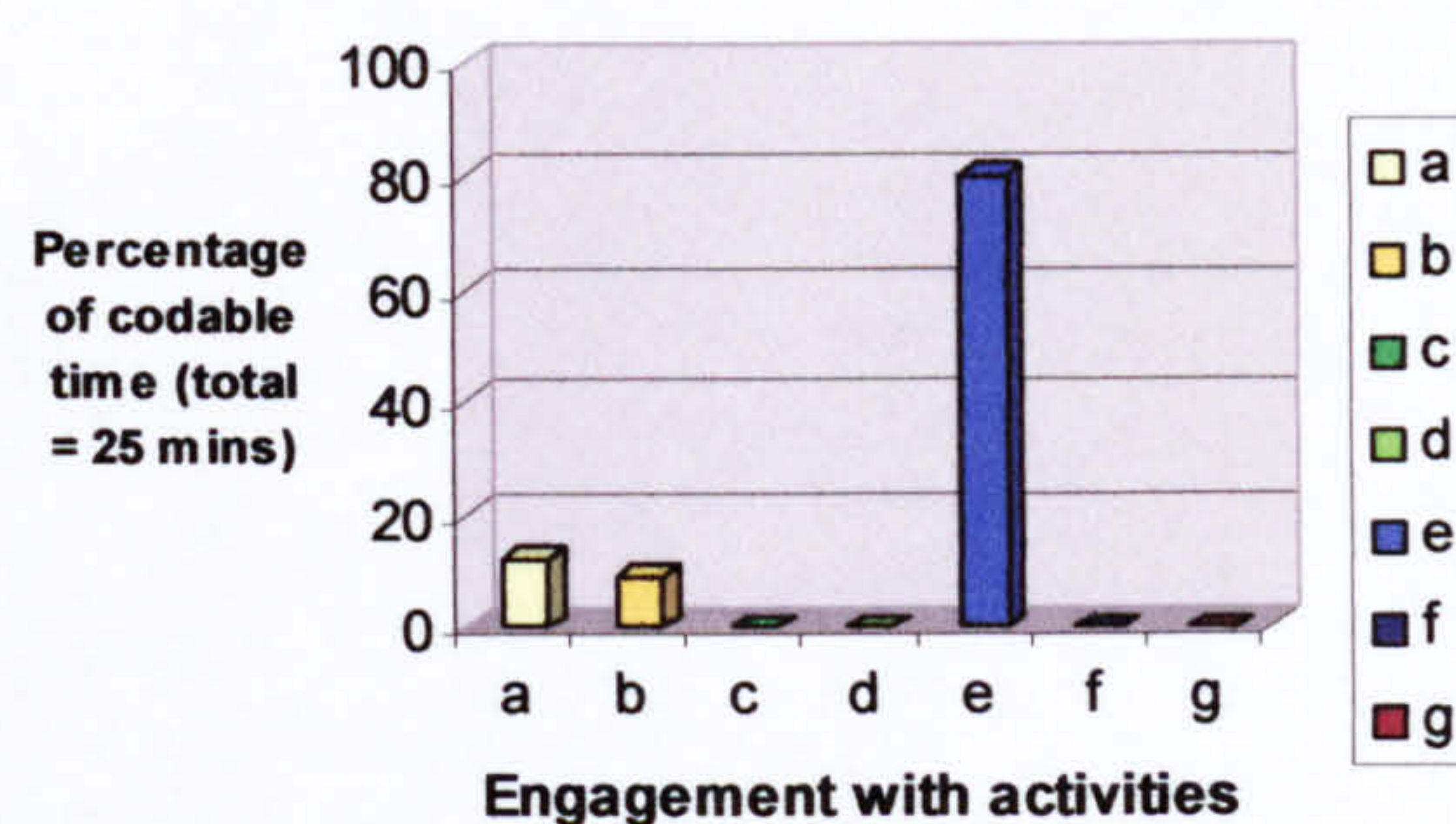
G - ISC 2 - activities



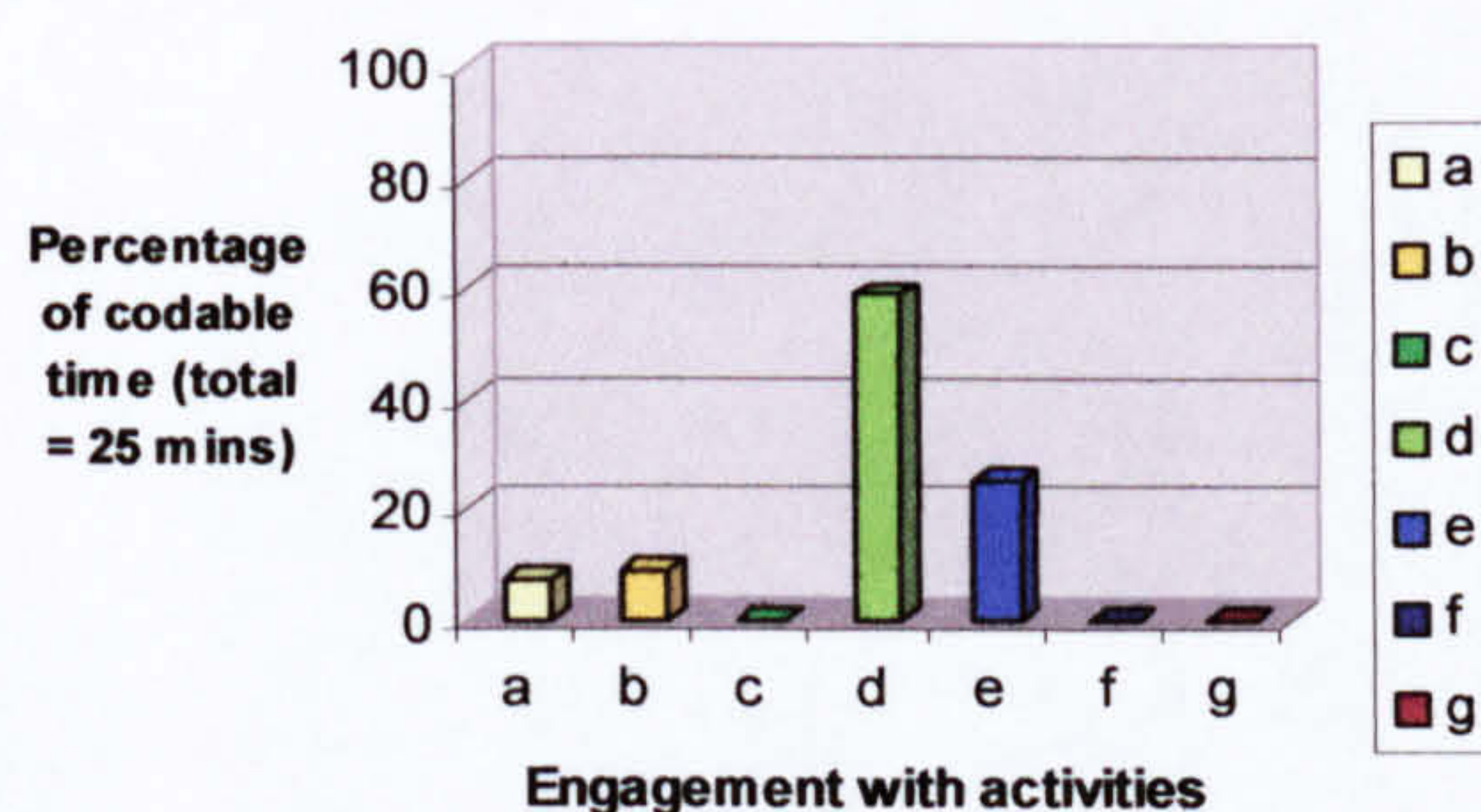
G - follow-up 2 - discussion



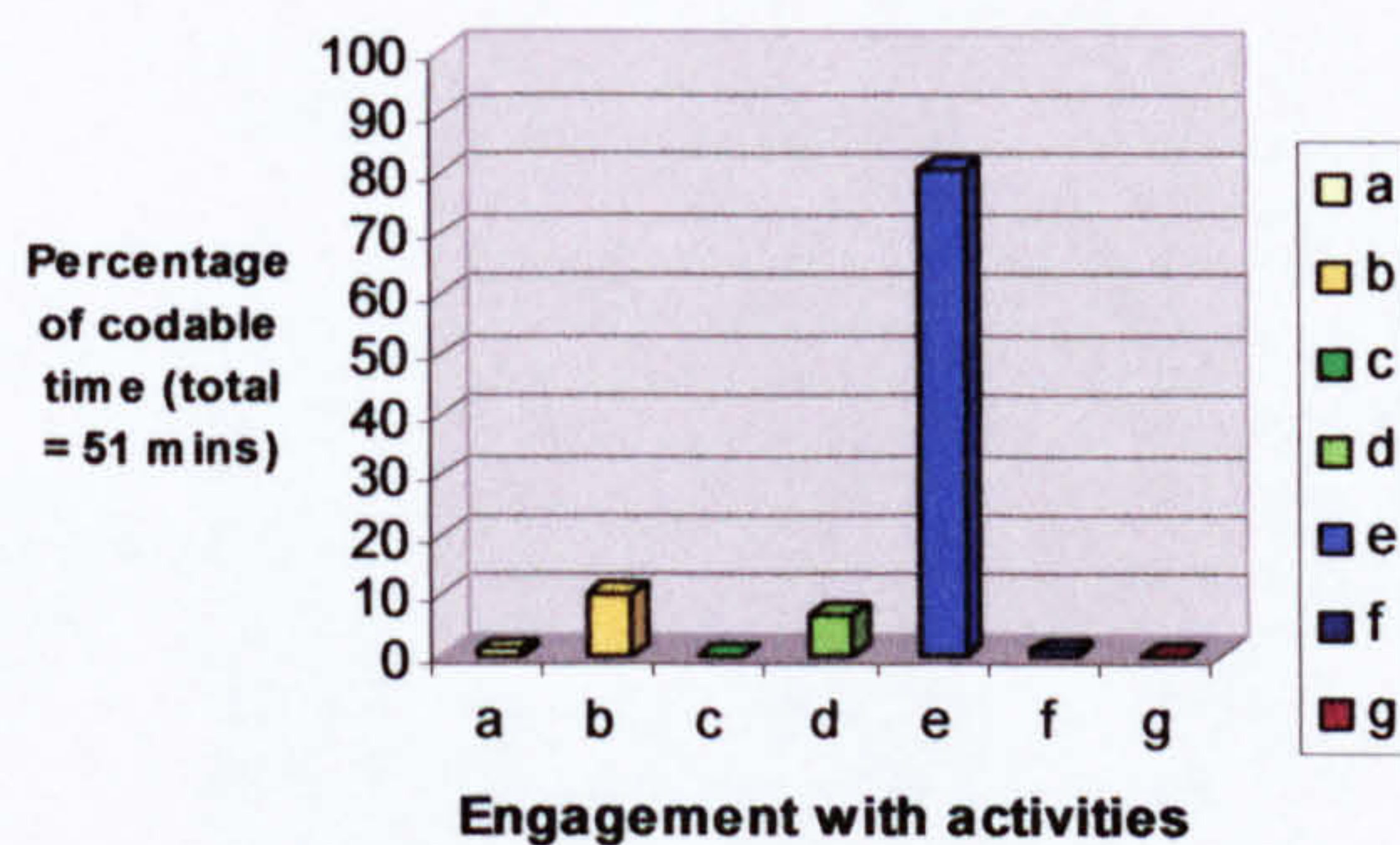
G - follow-up 2 - activities



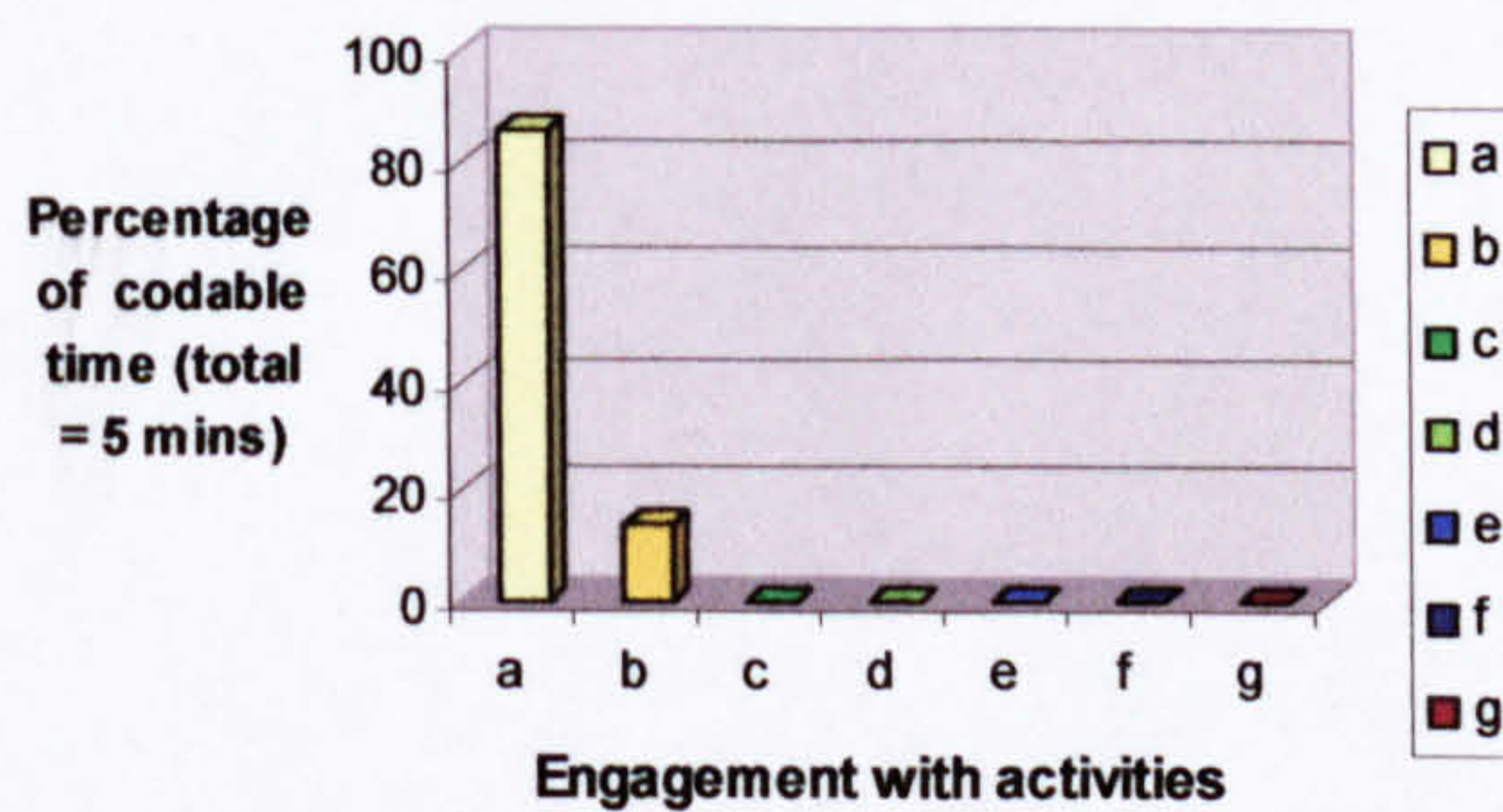
G - college 2



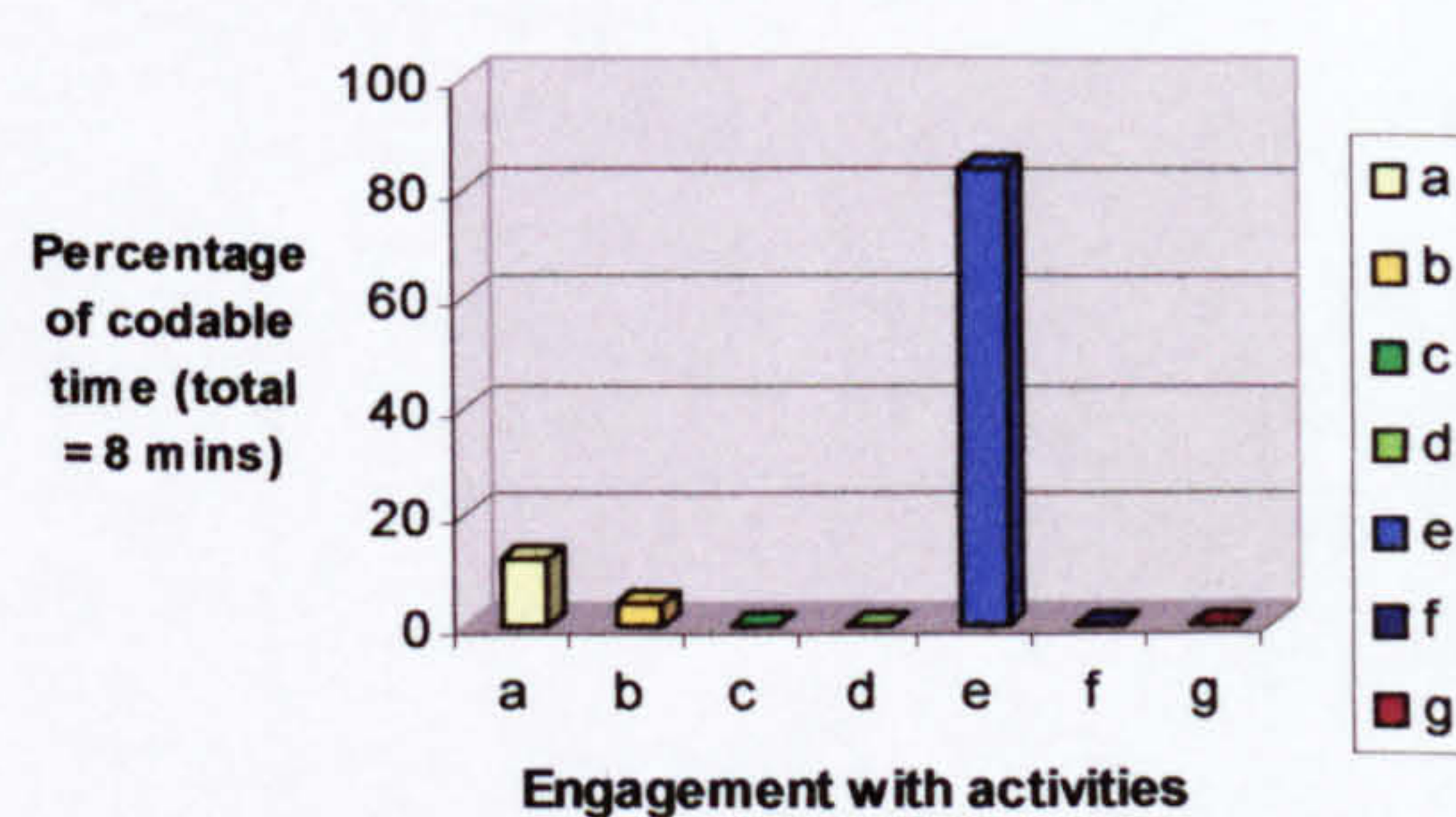
G - ISC 3 - activities

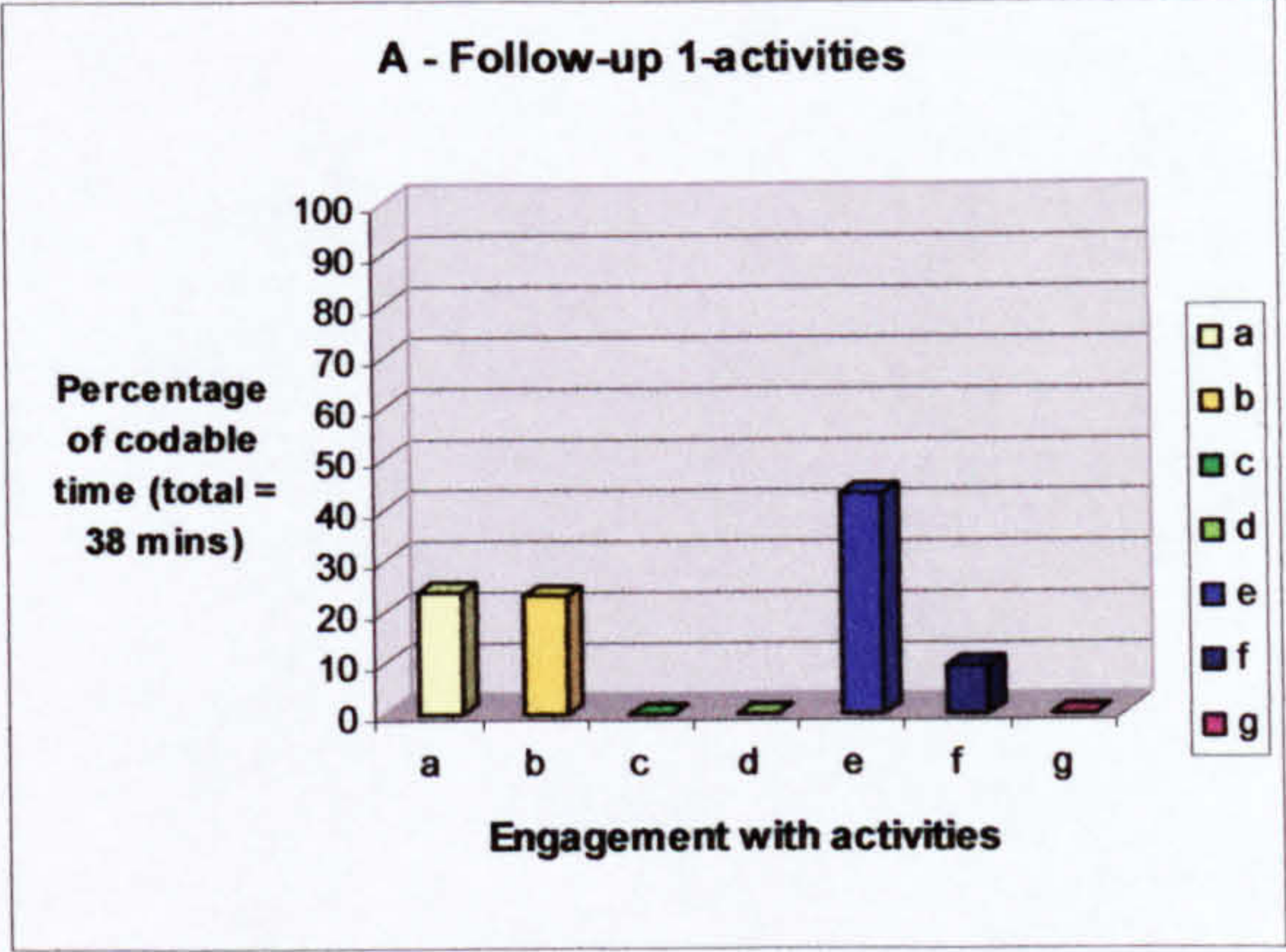
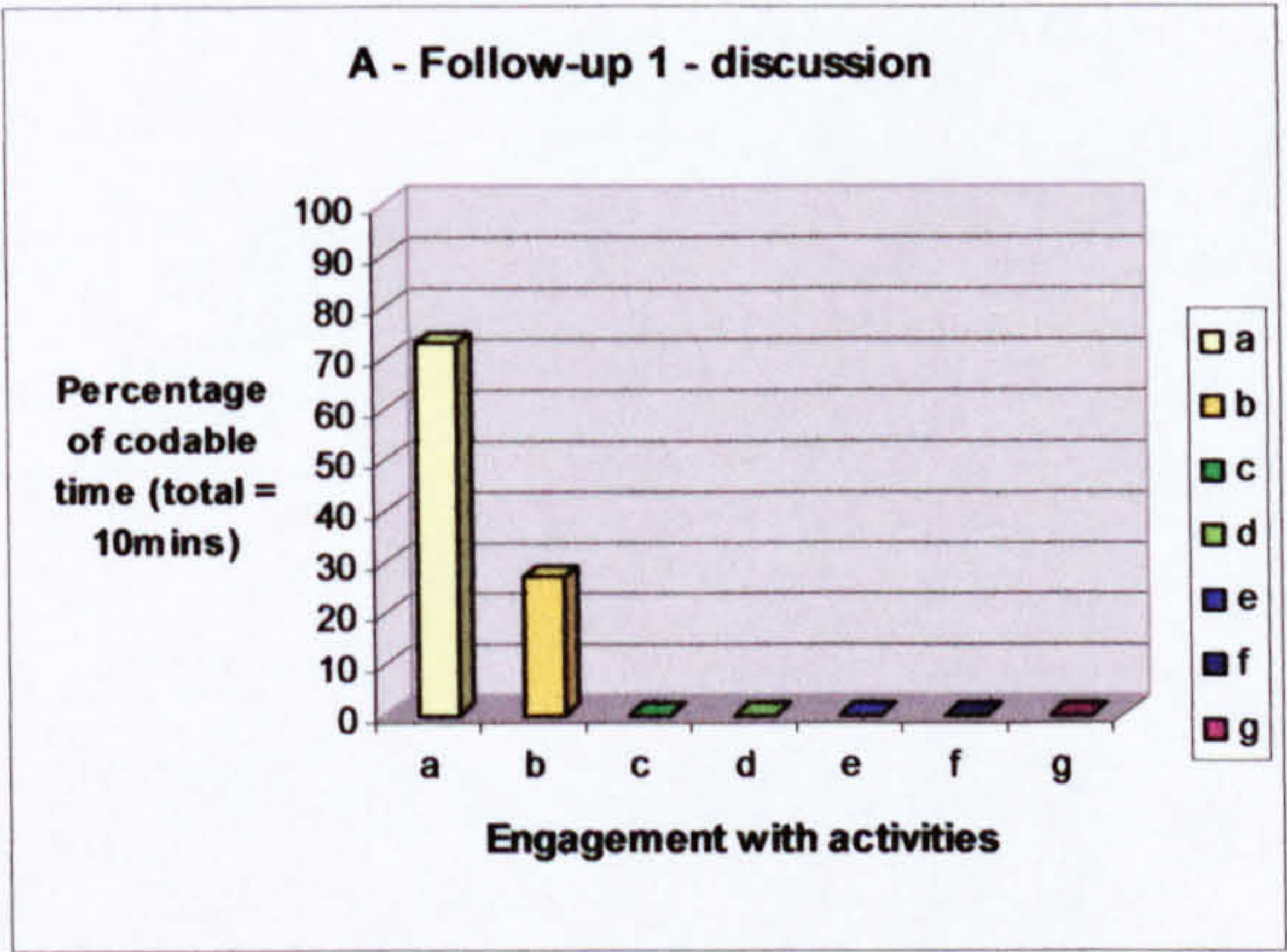
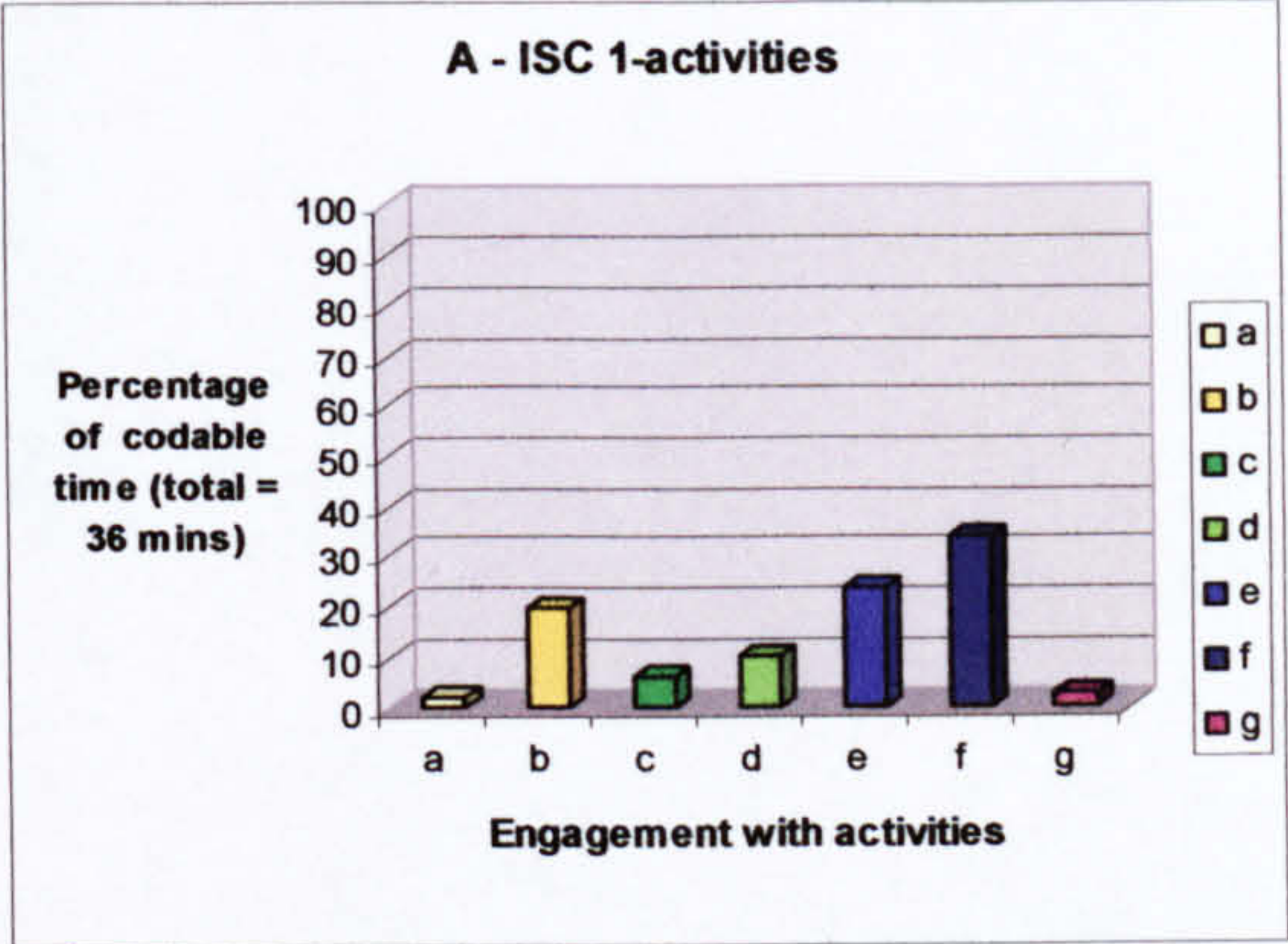
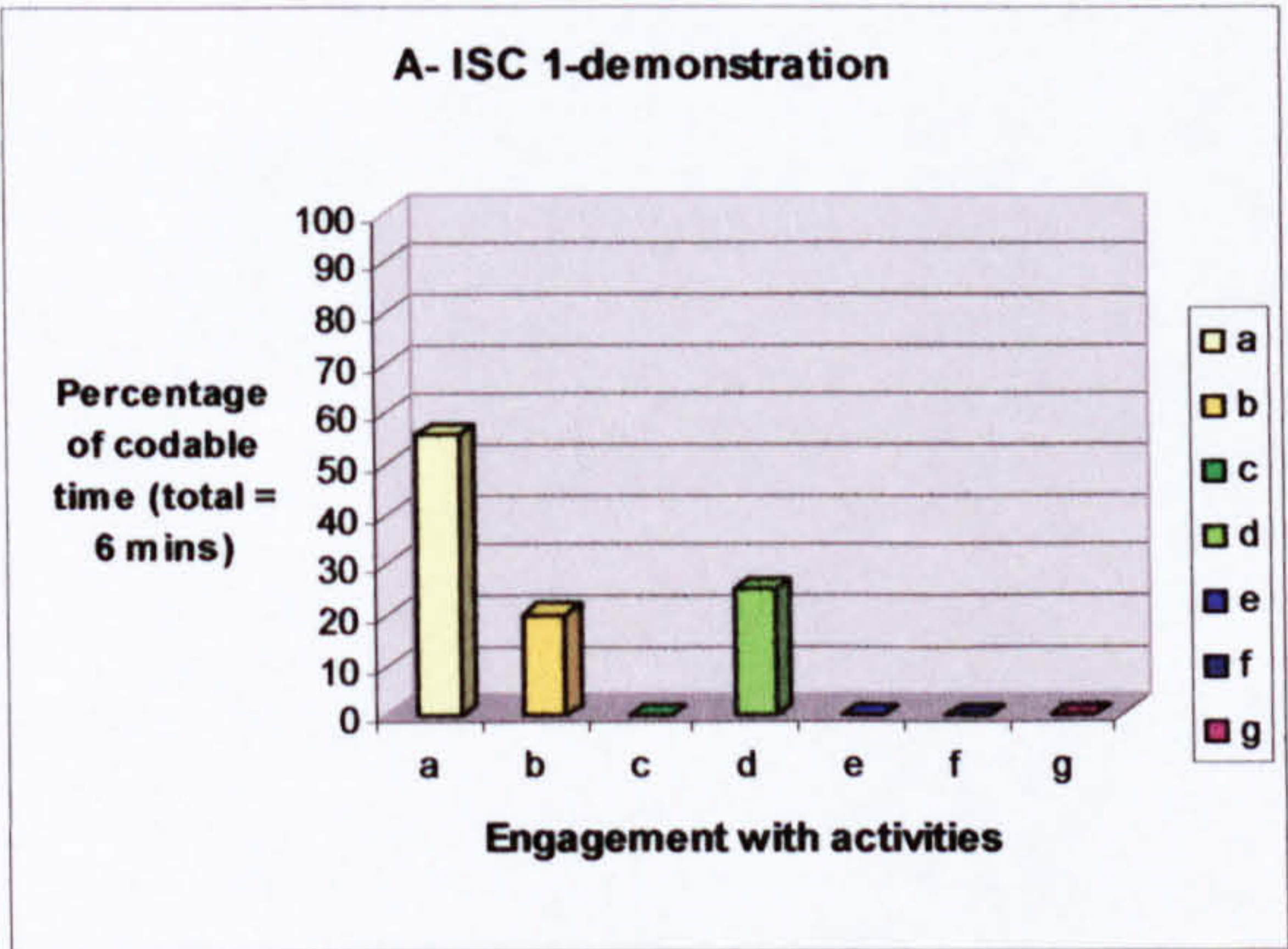
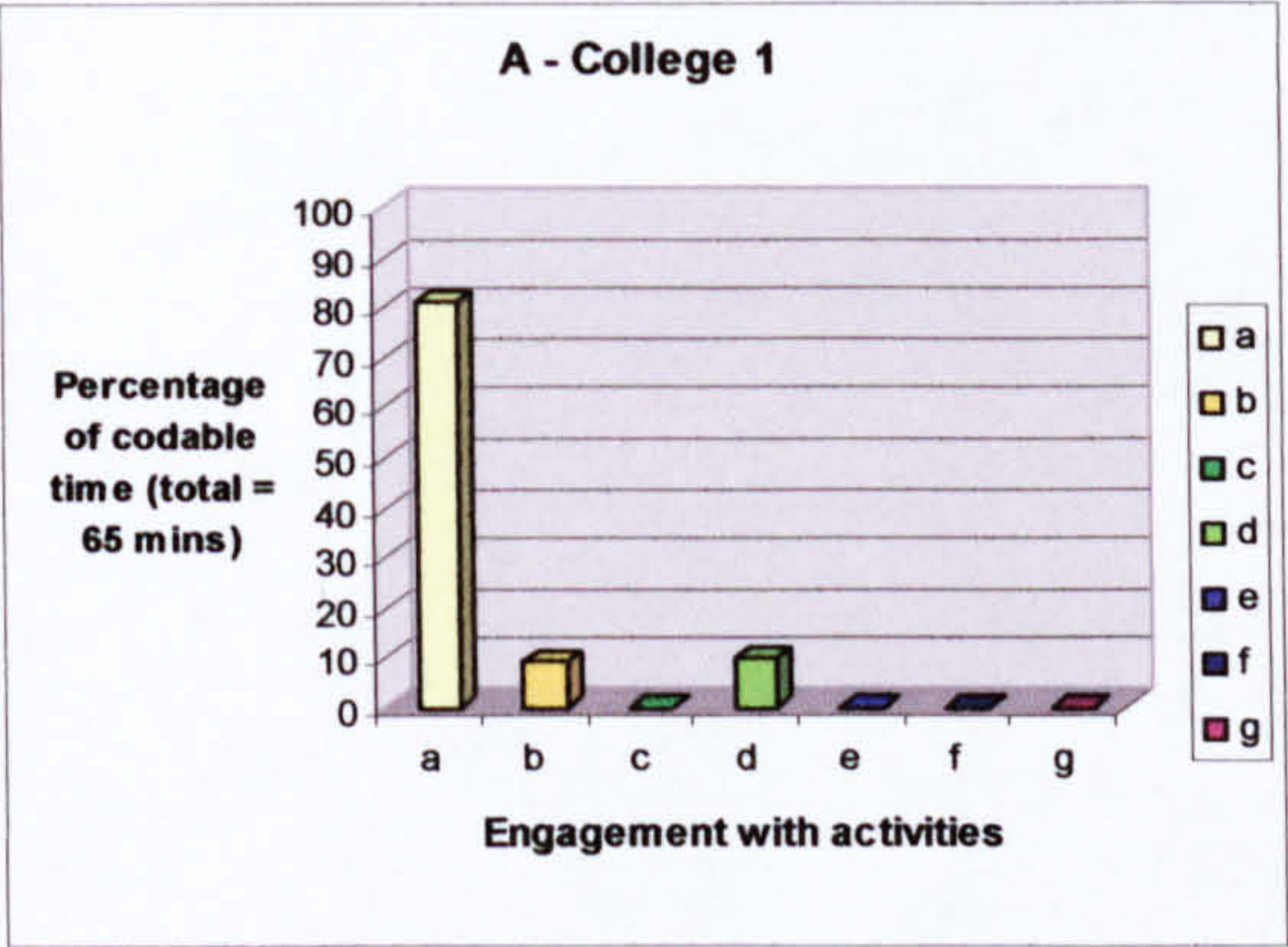


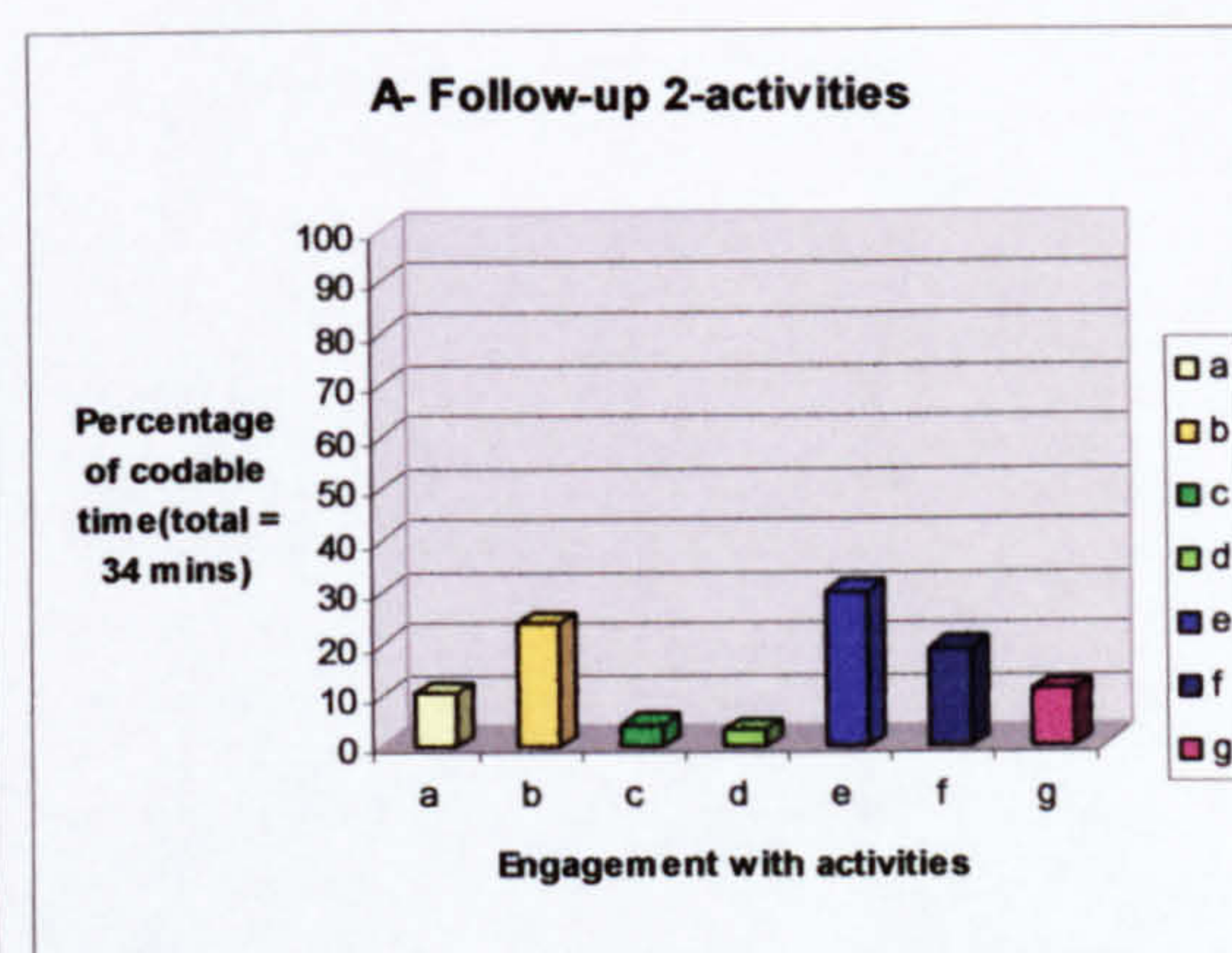
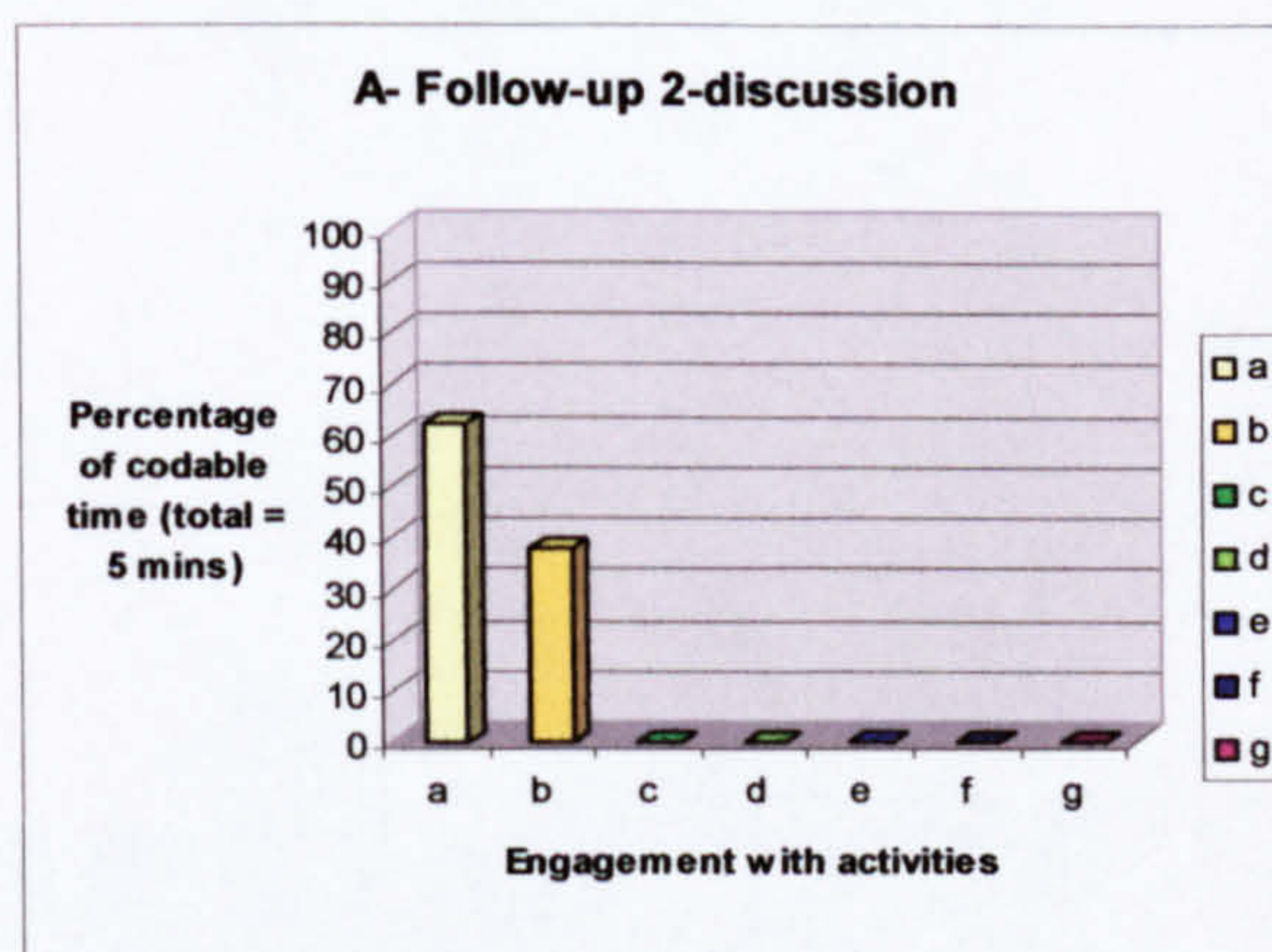
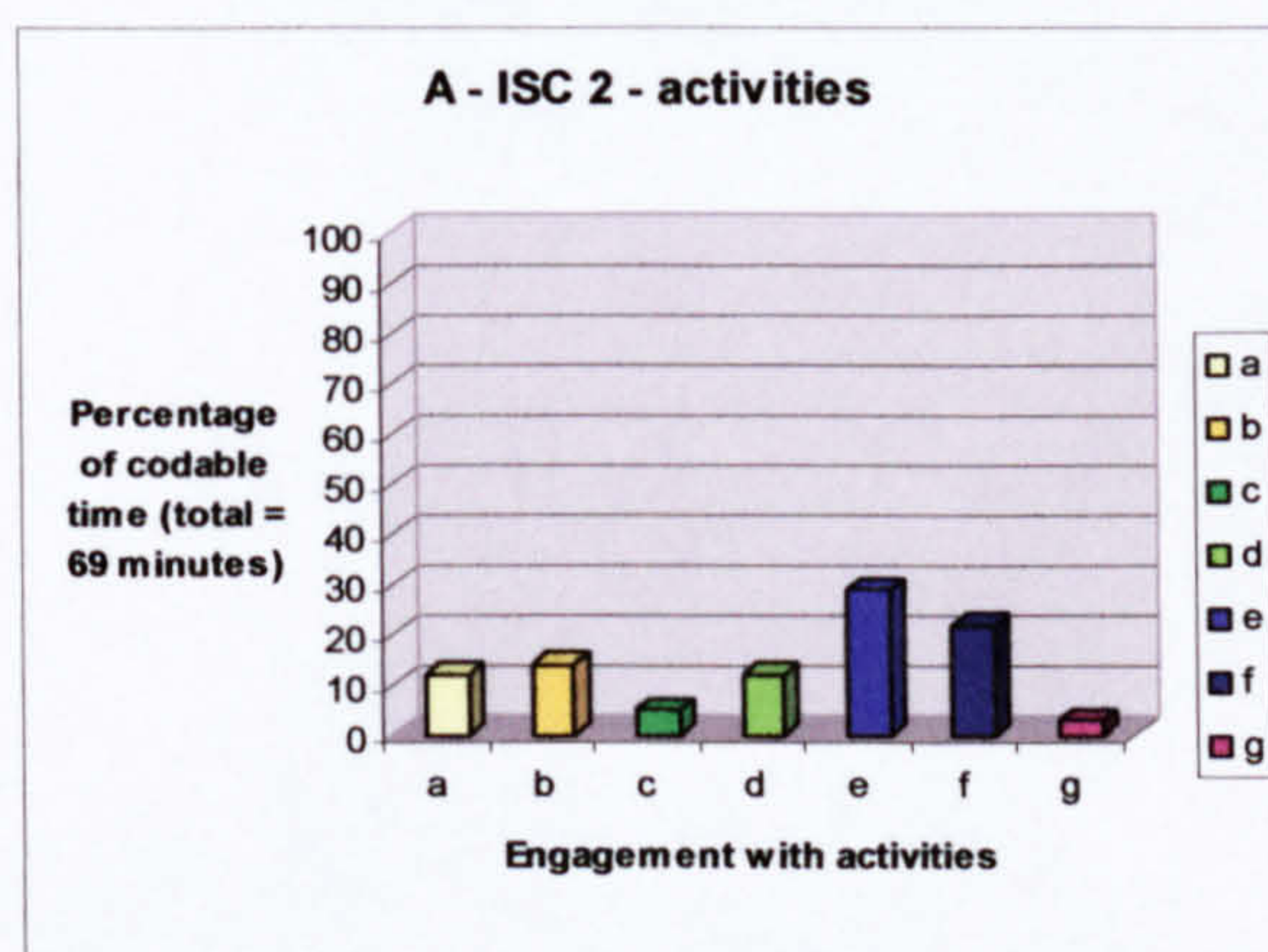
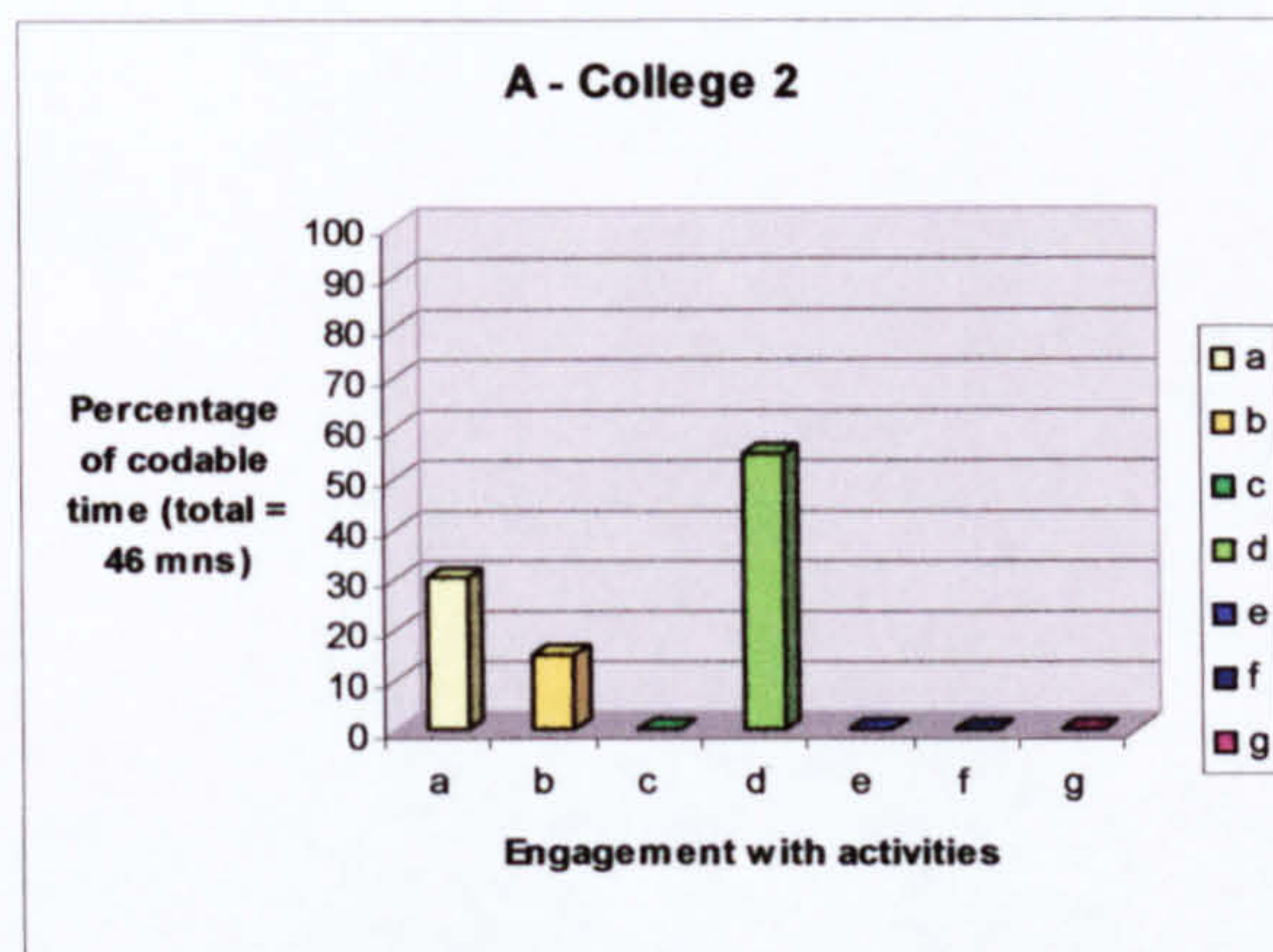
G- follow-up 3 - discussion



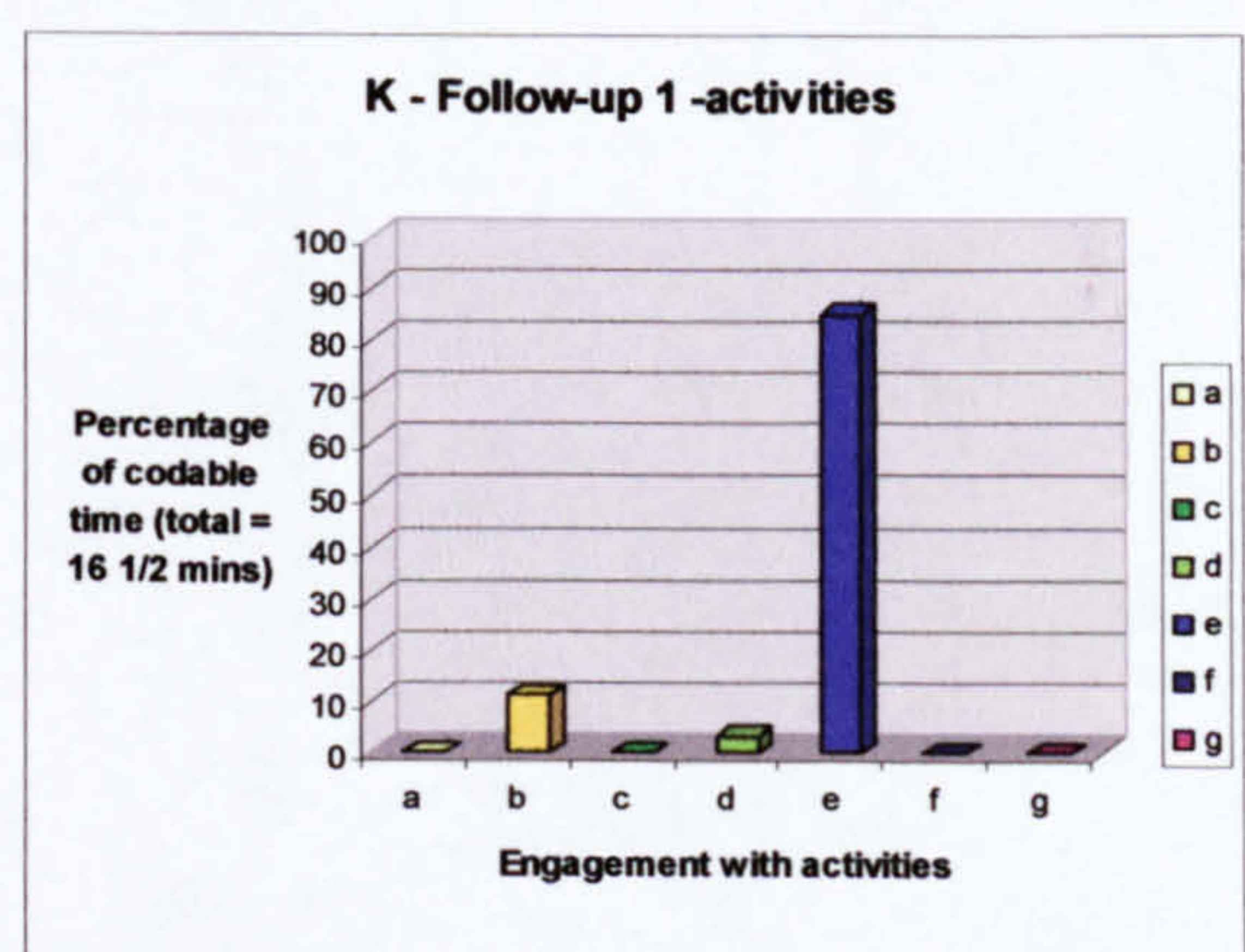
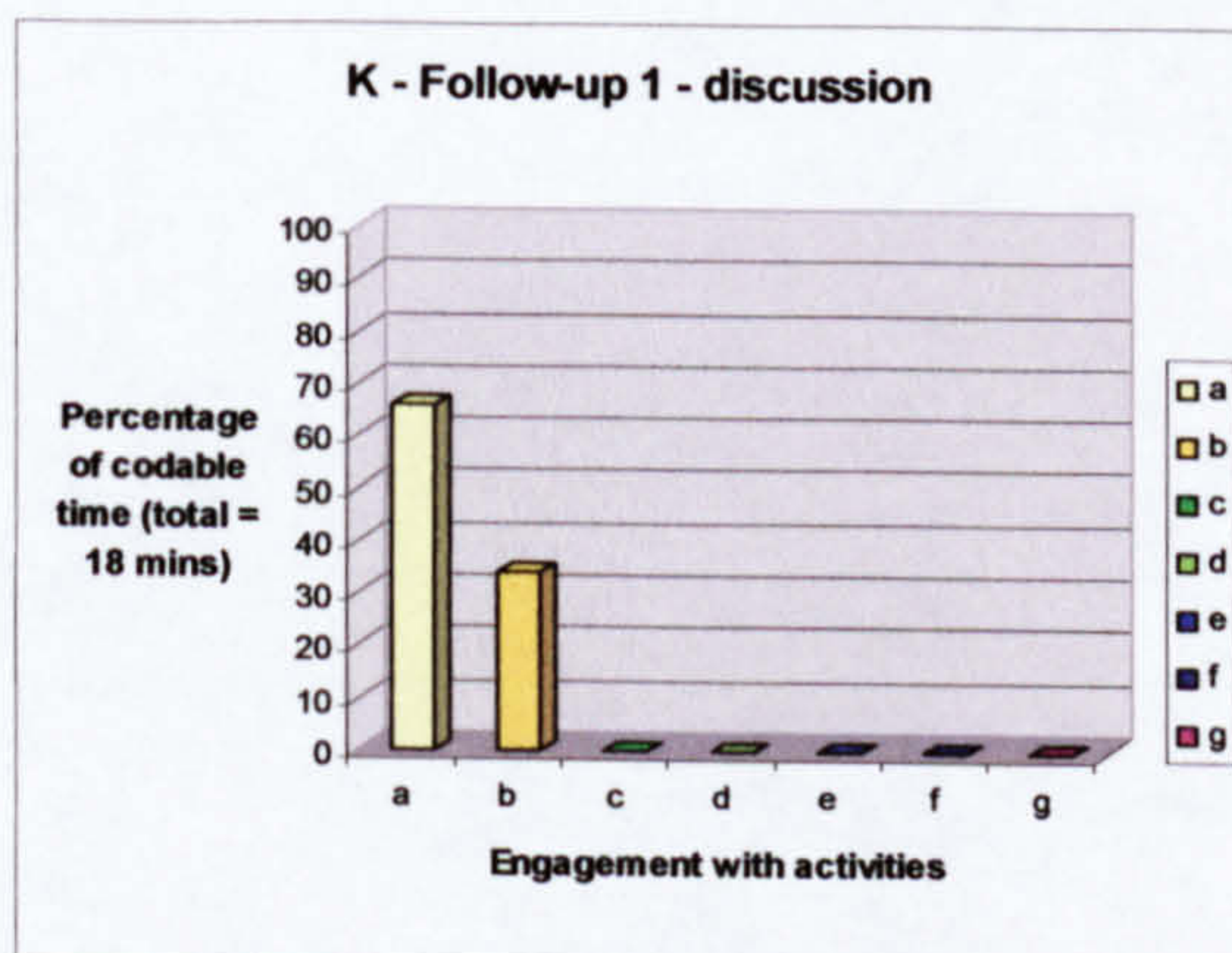
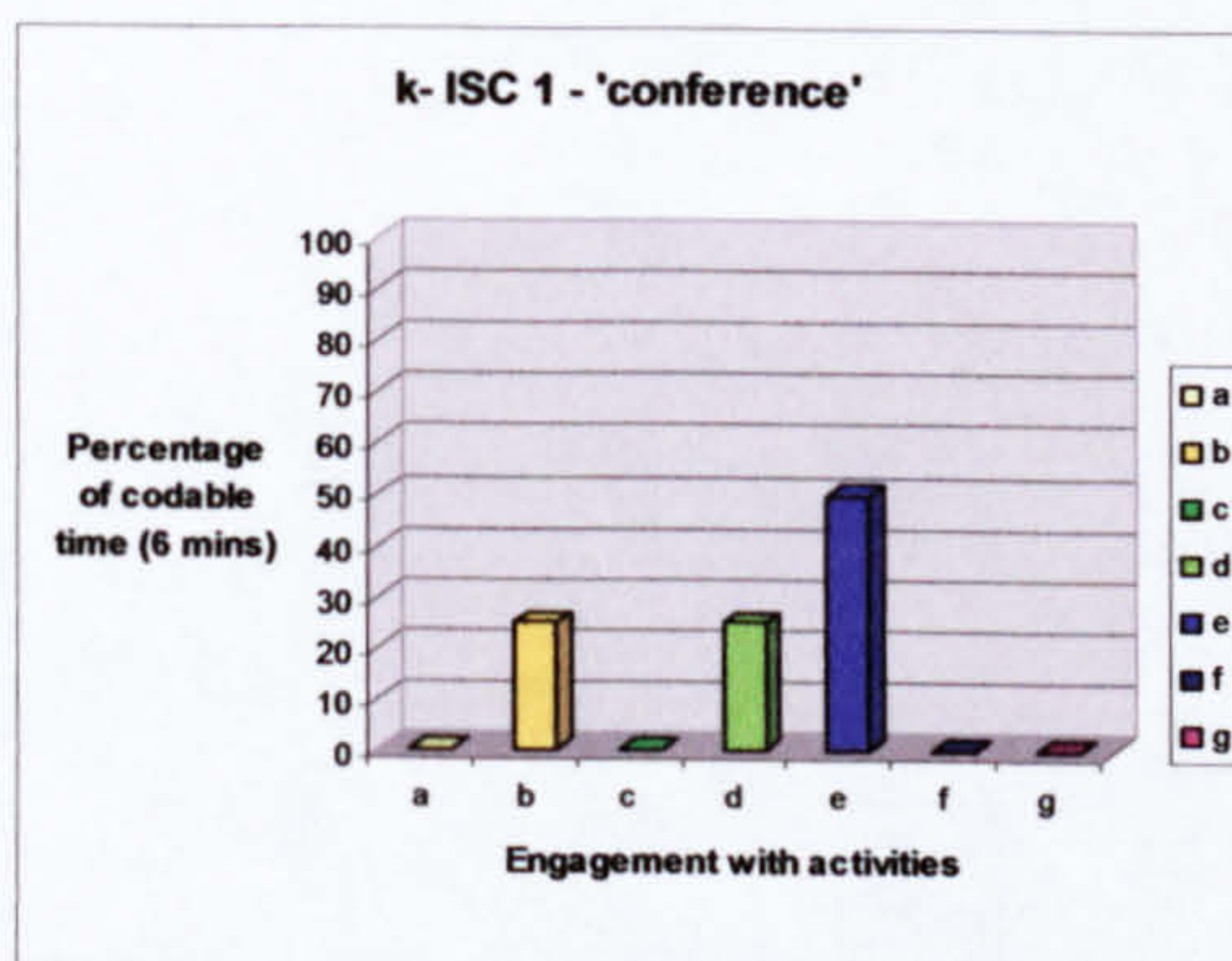
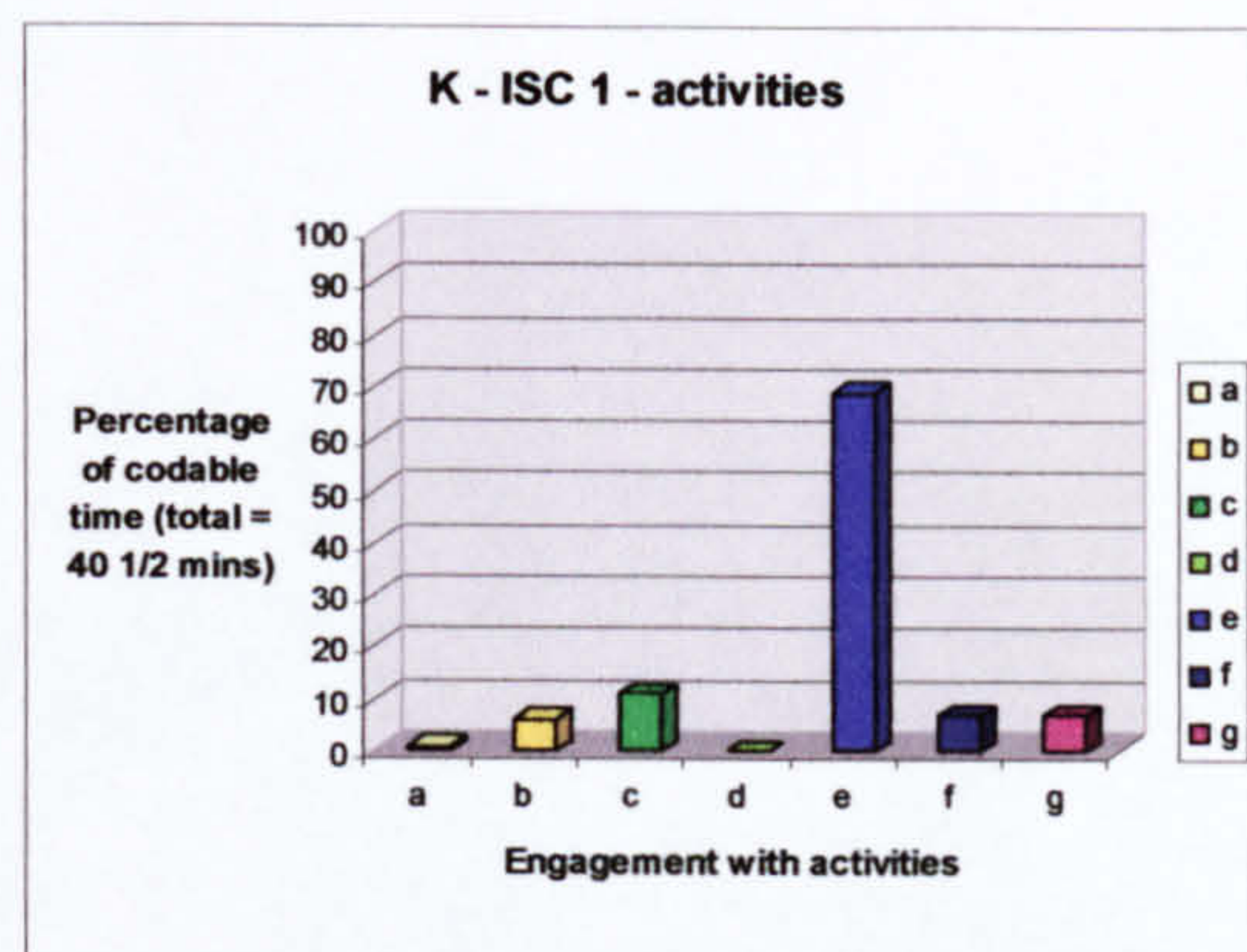
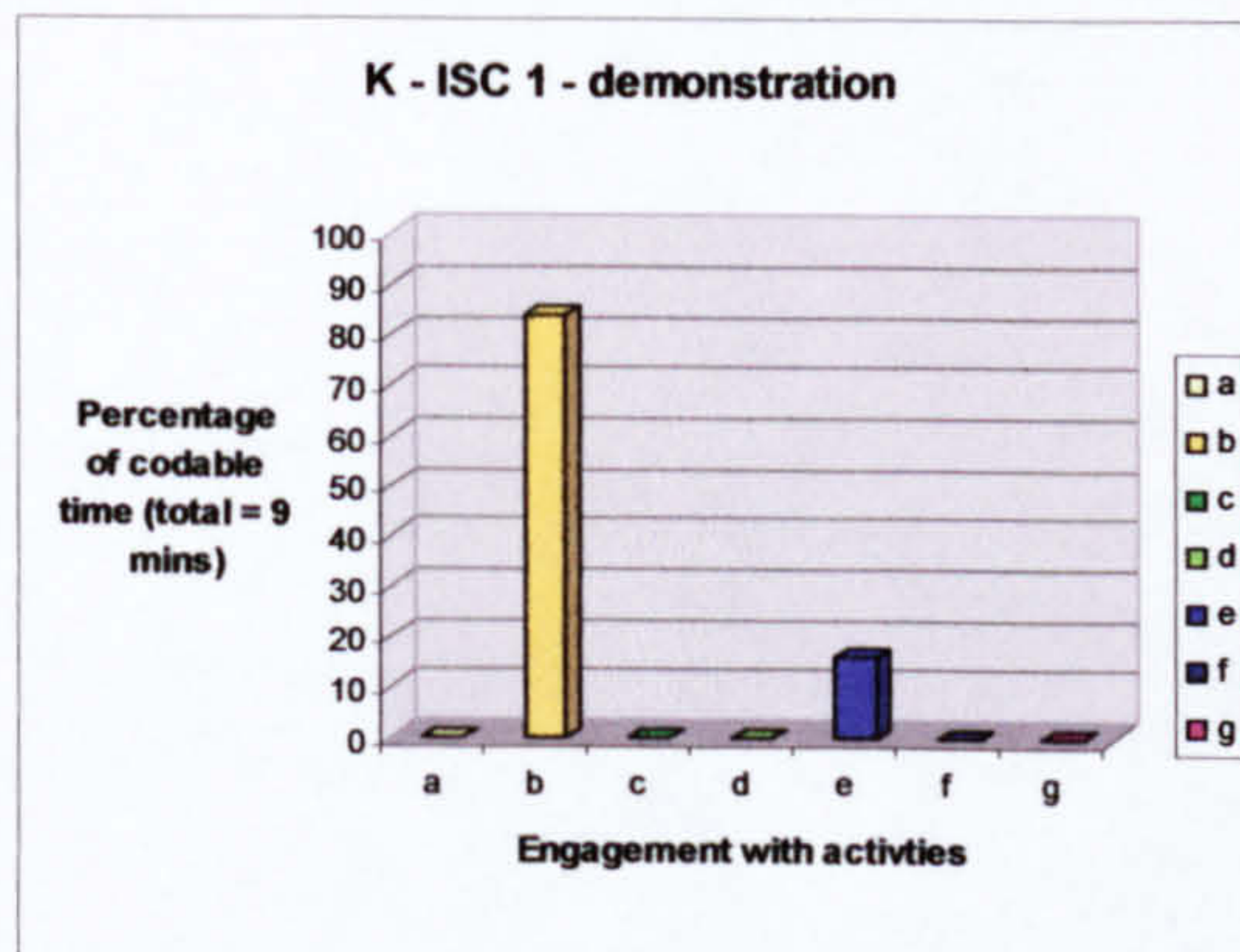
G - follow-up 3 - activities

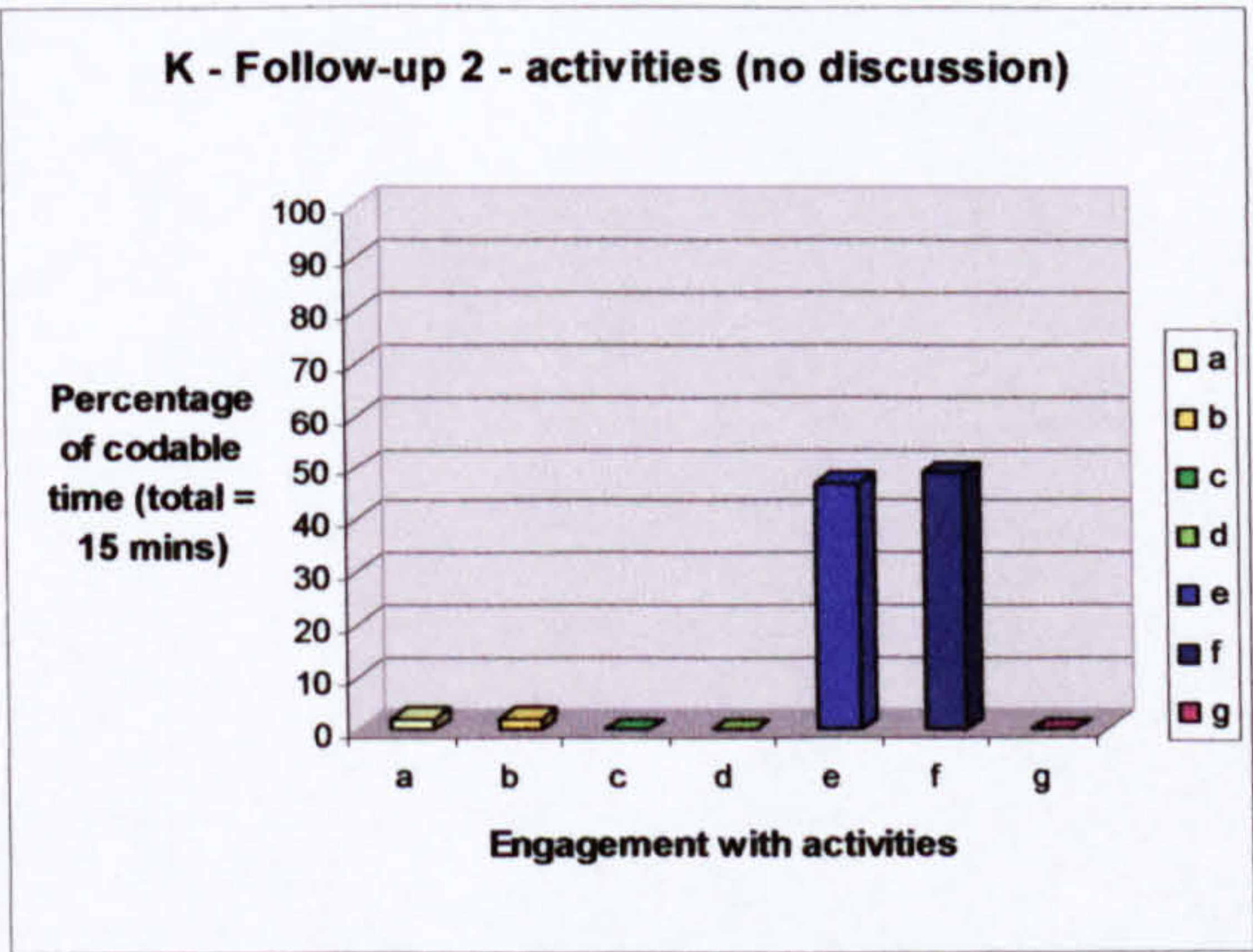
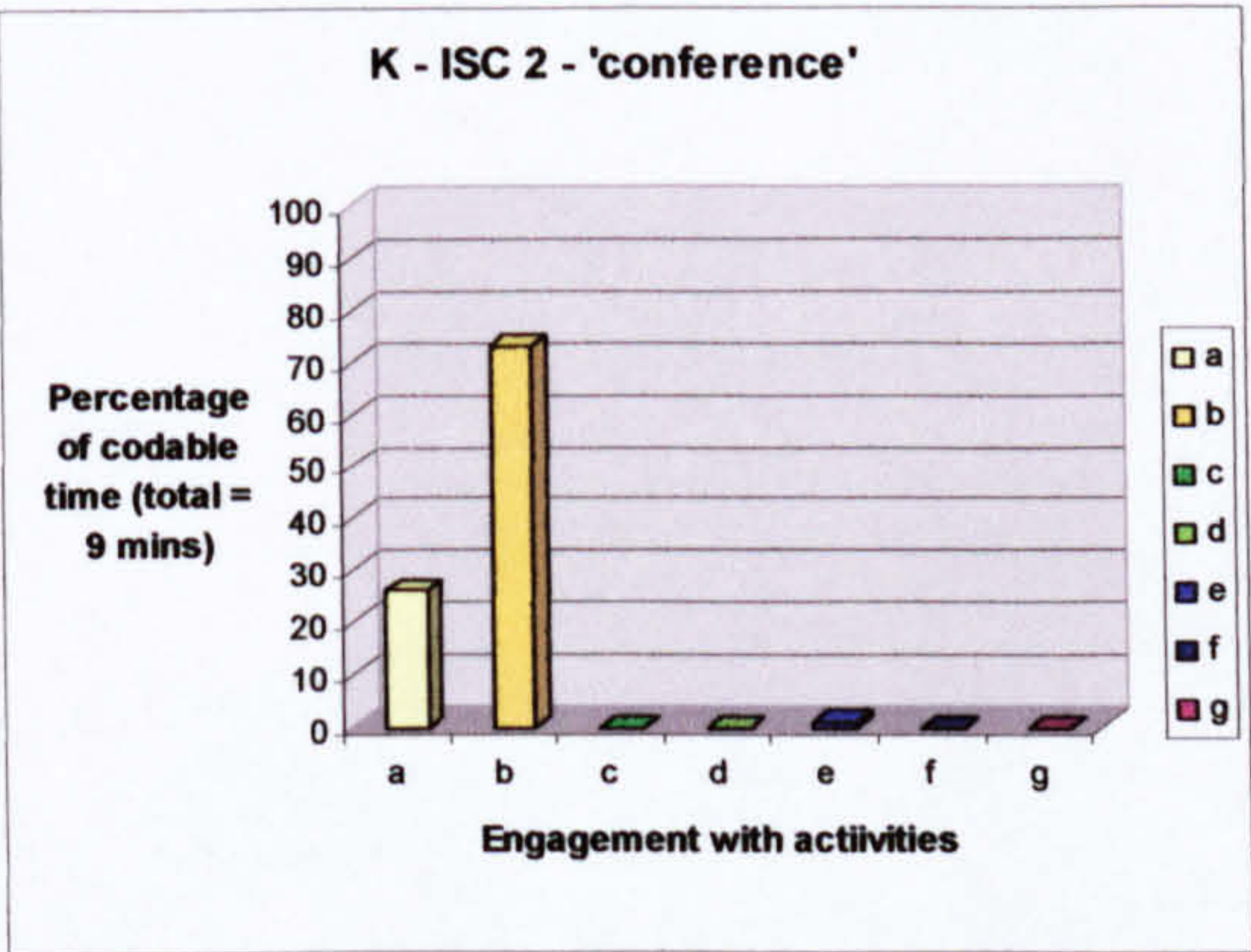
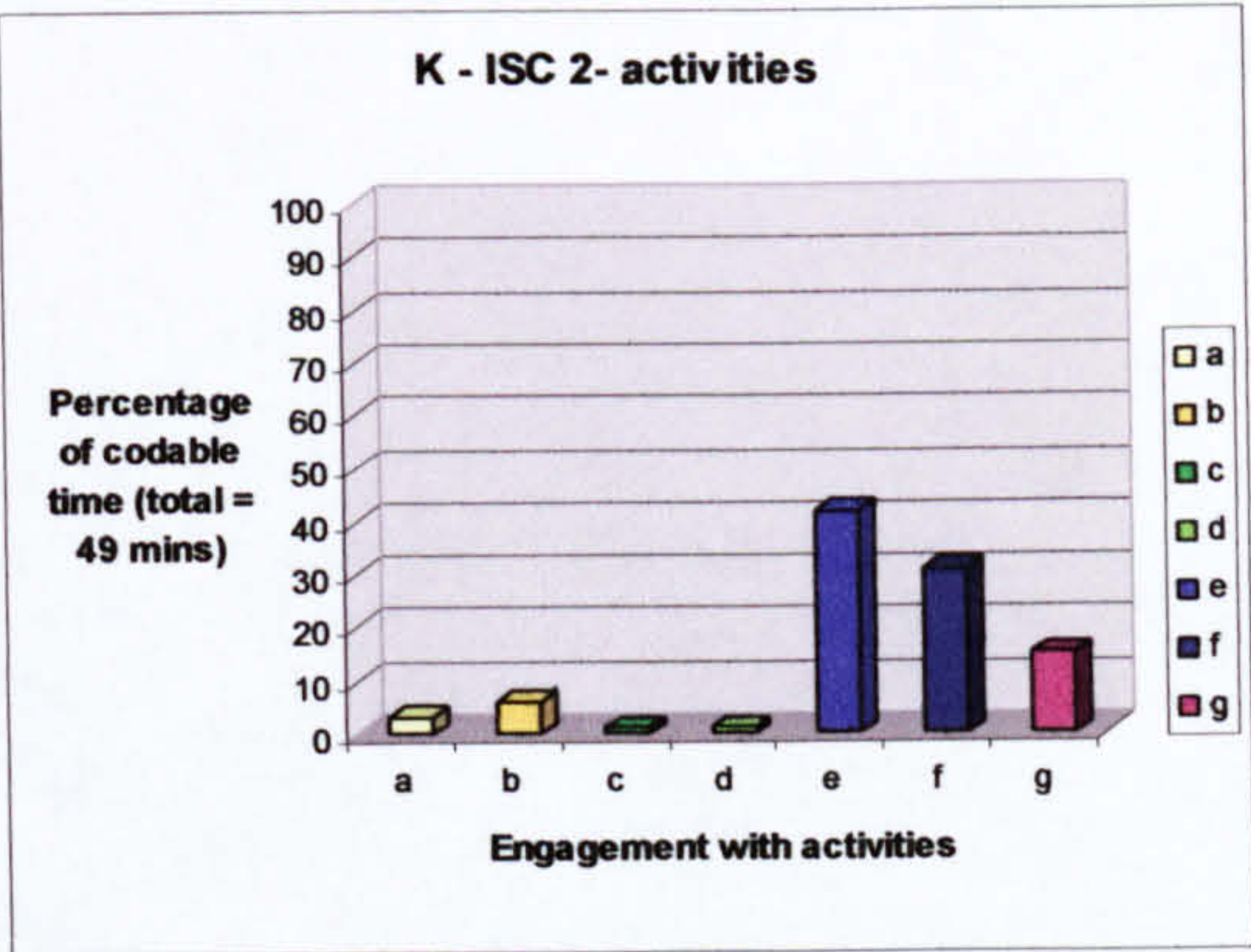
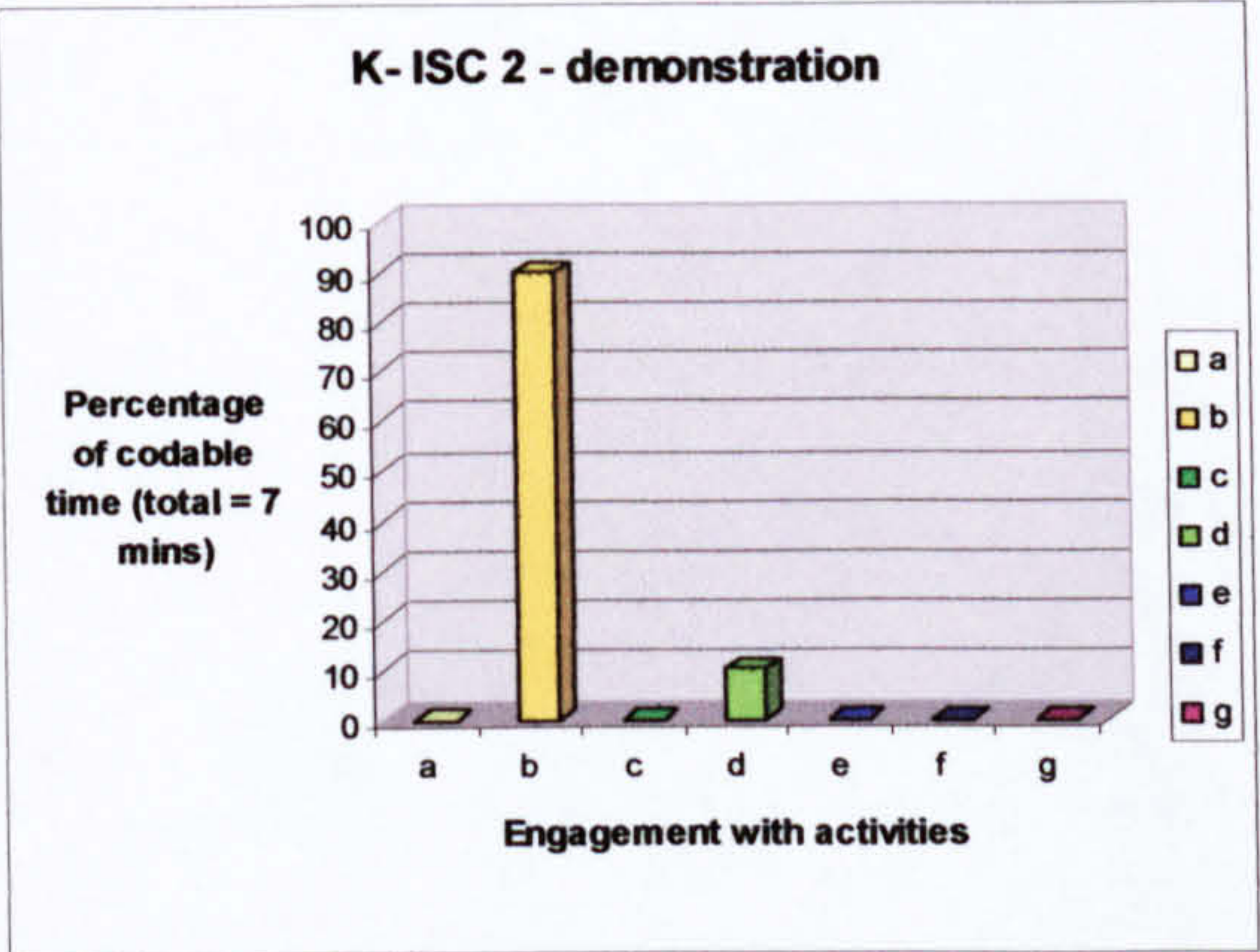
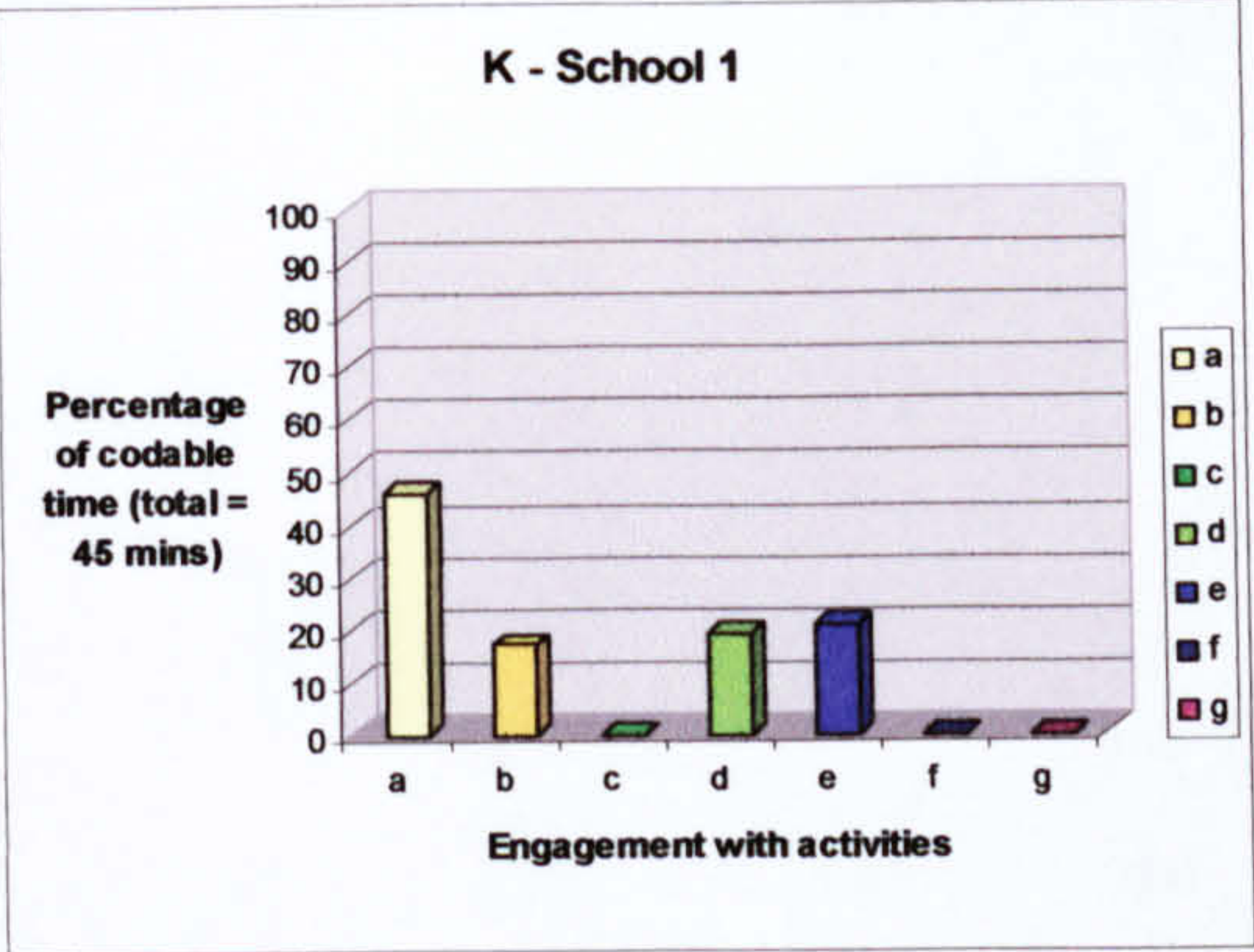


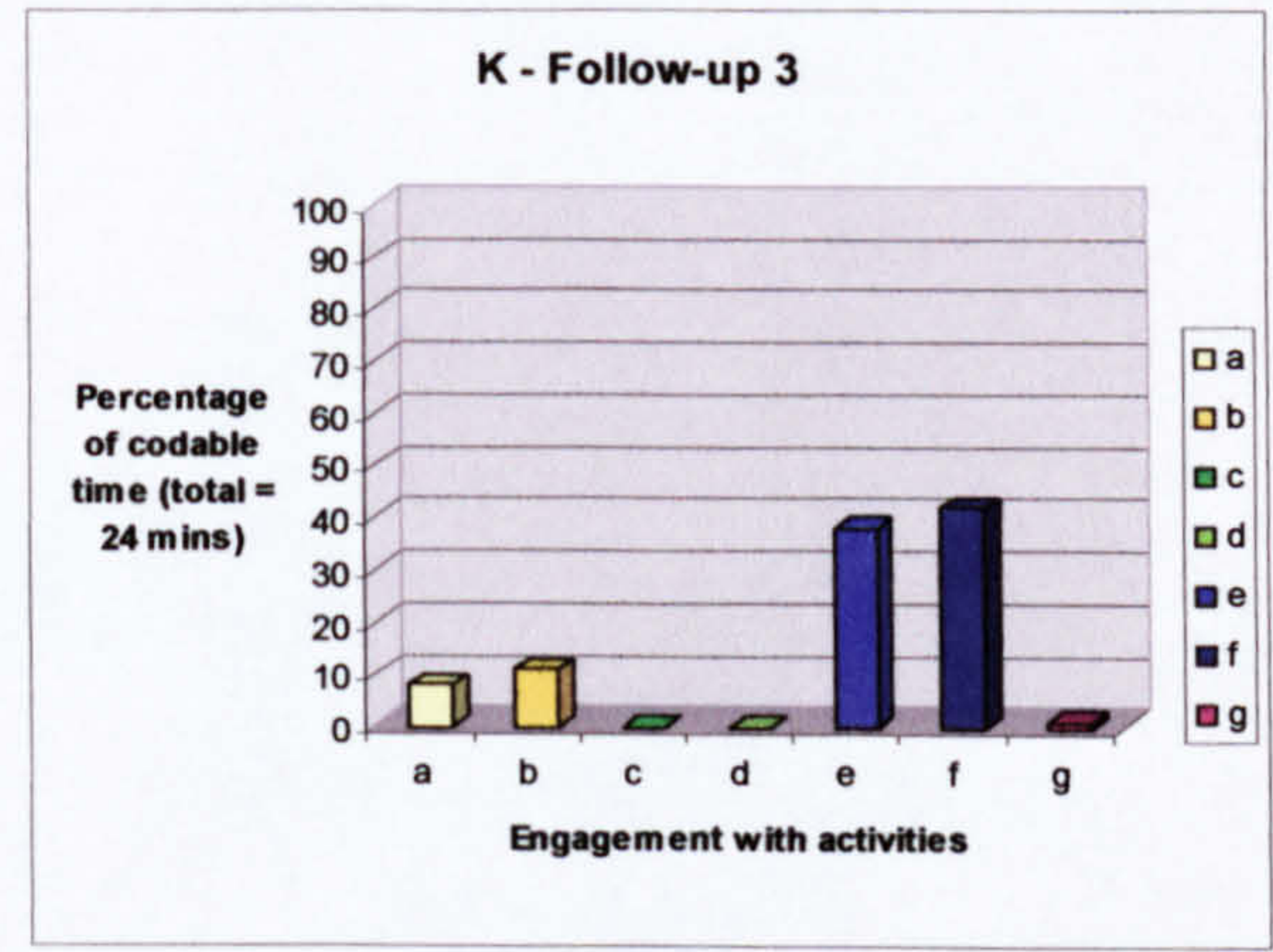
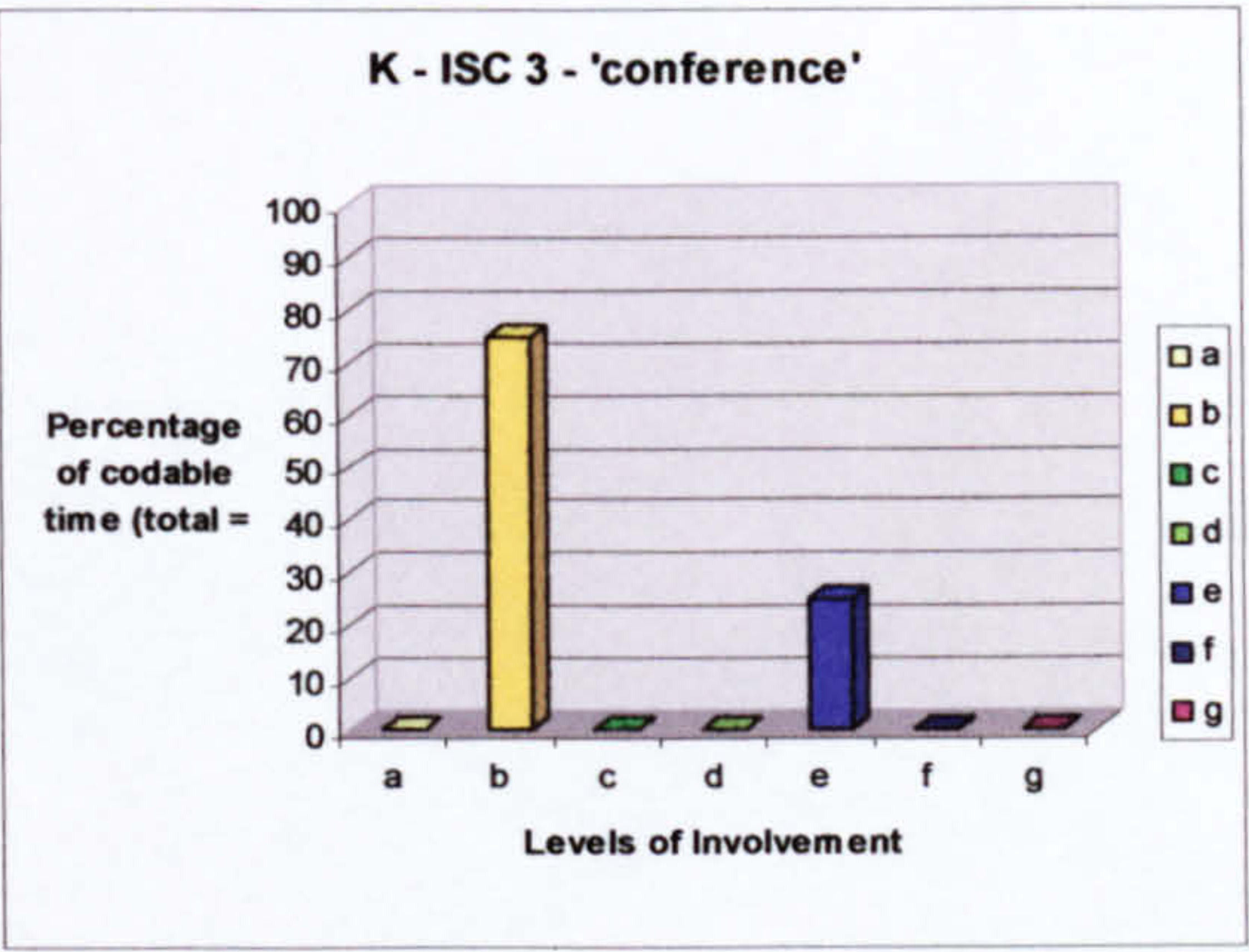
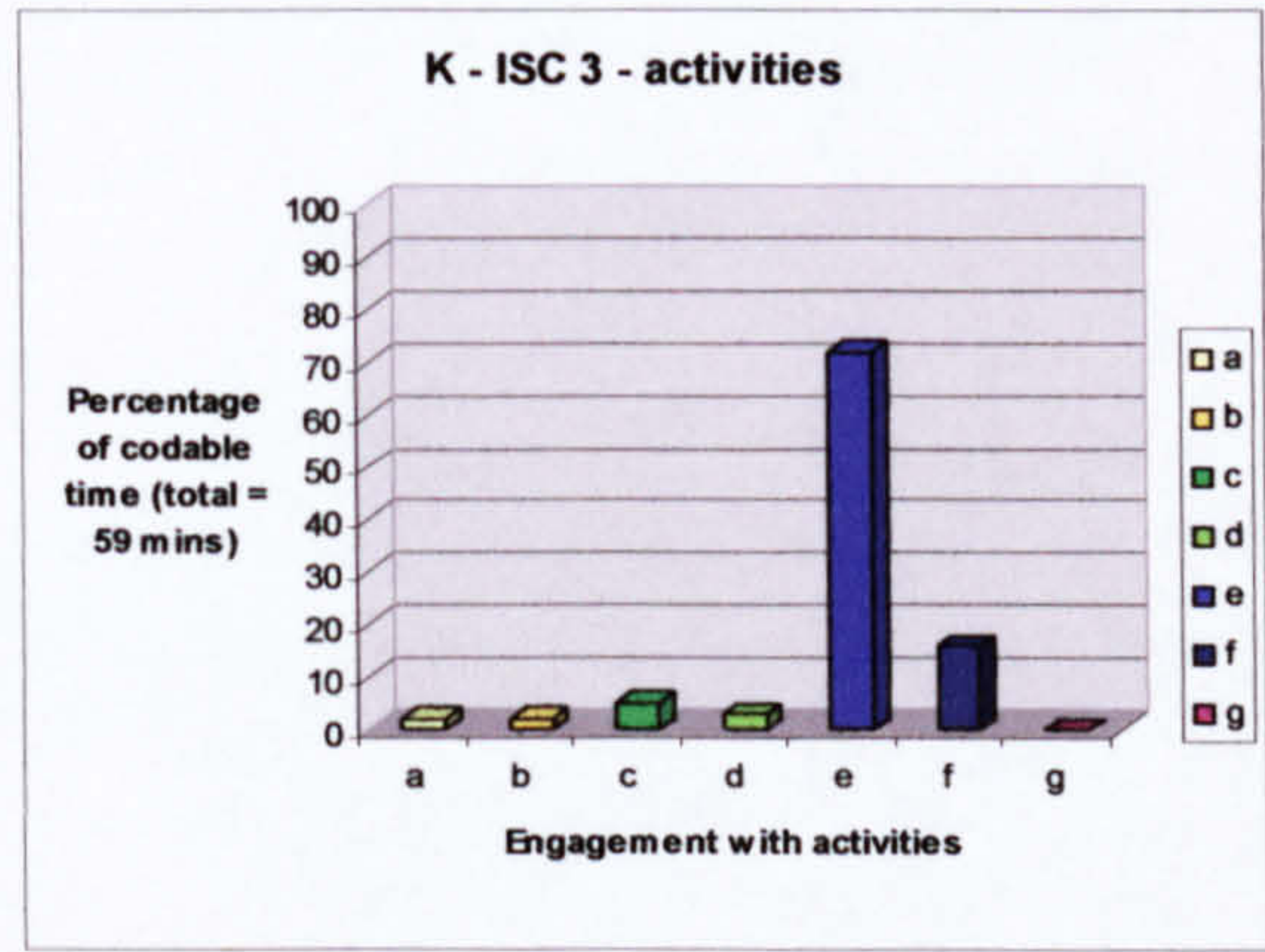
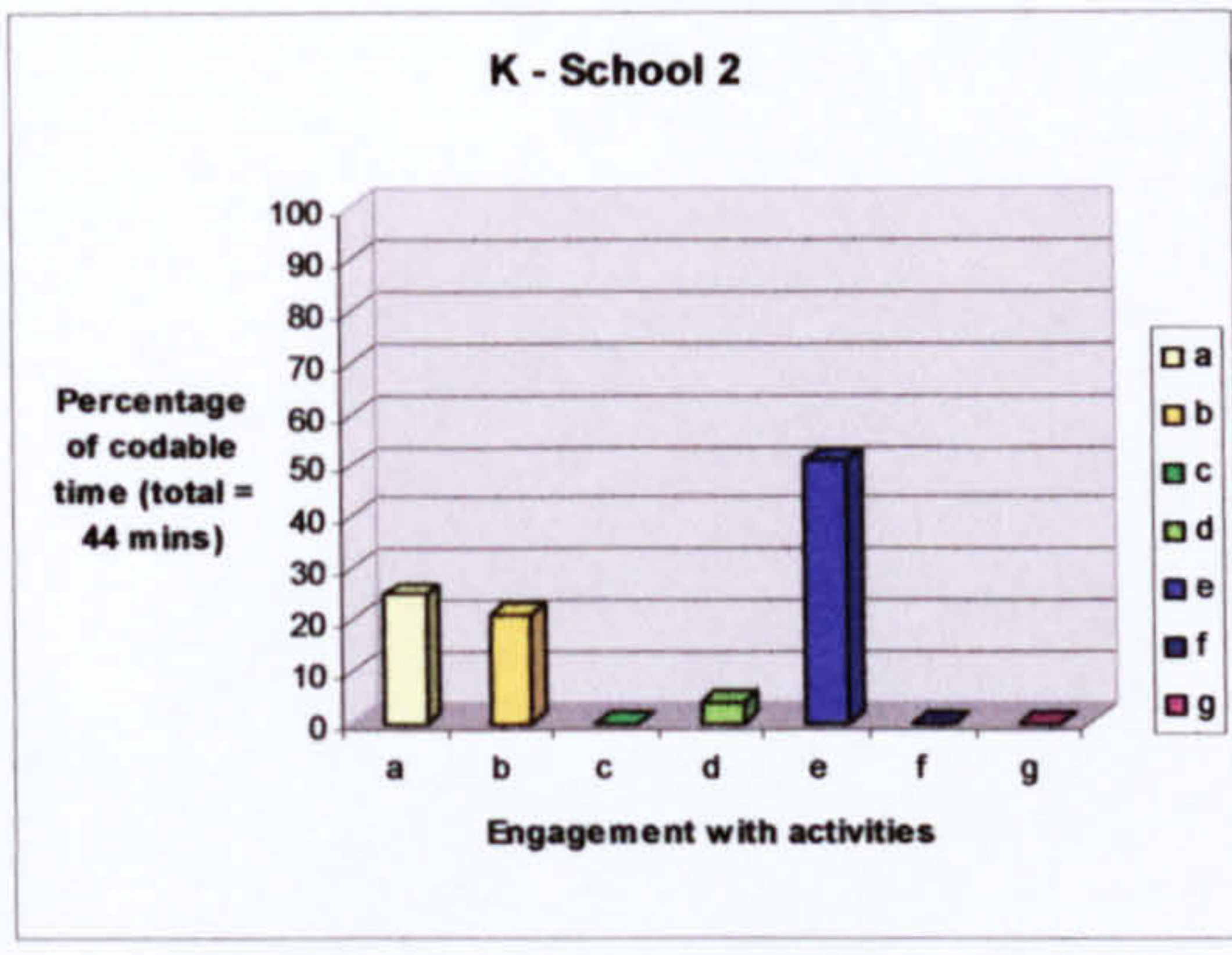




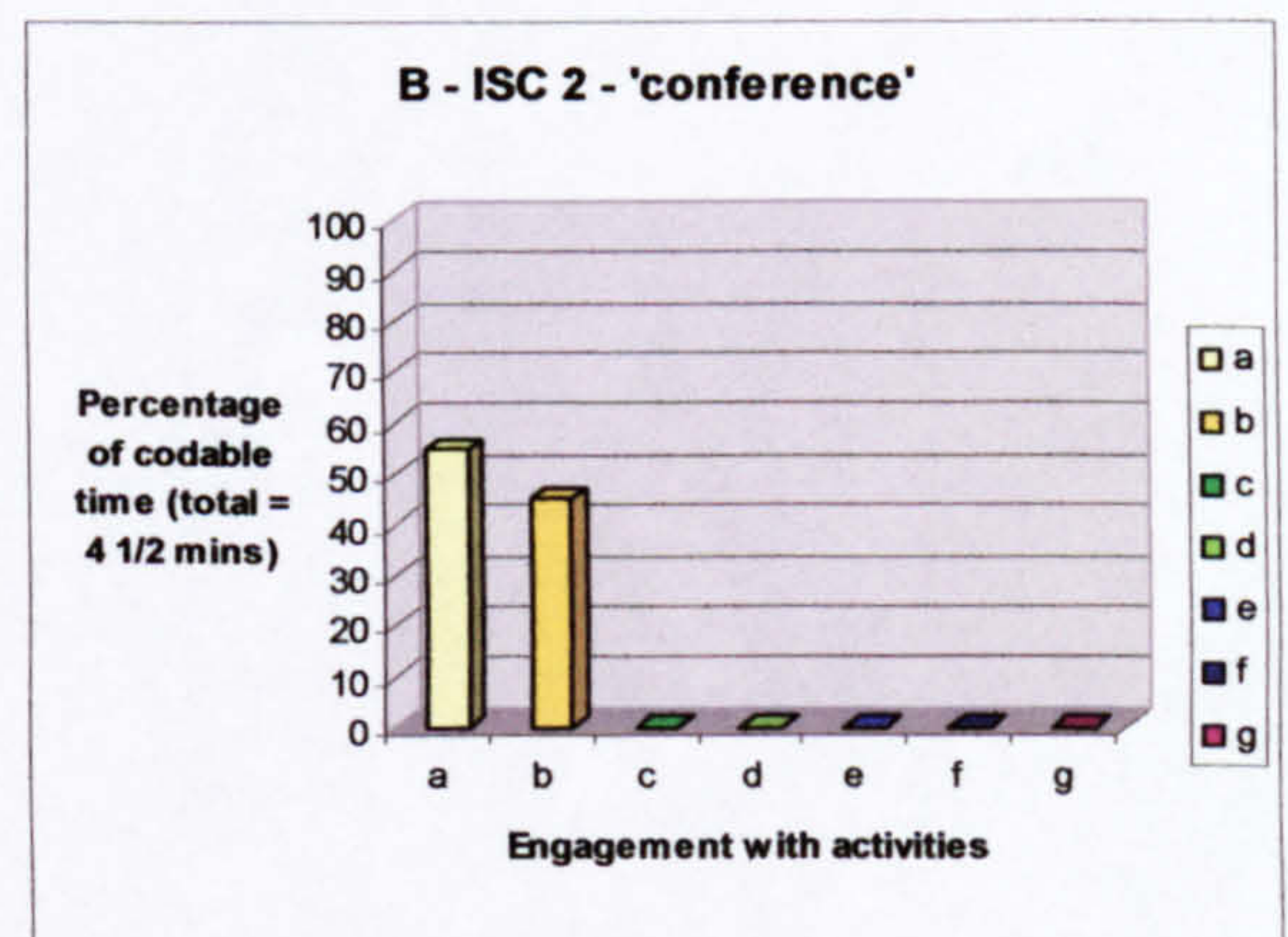
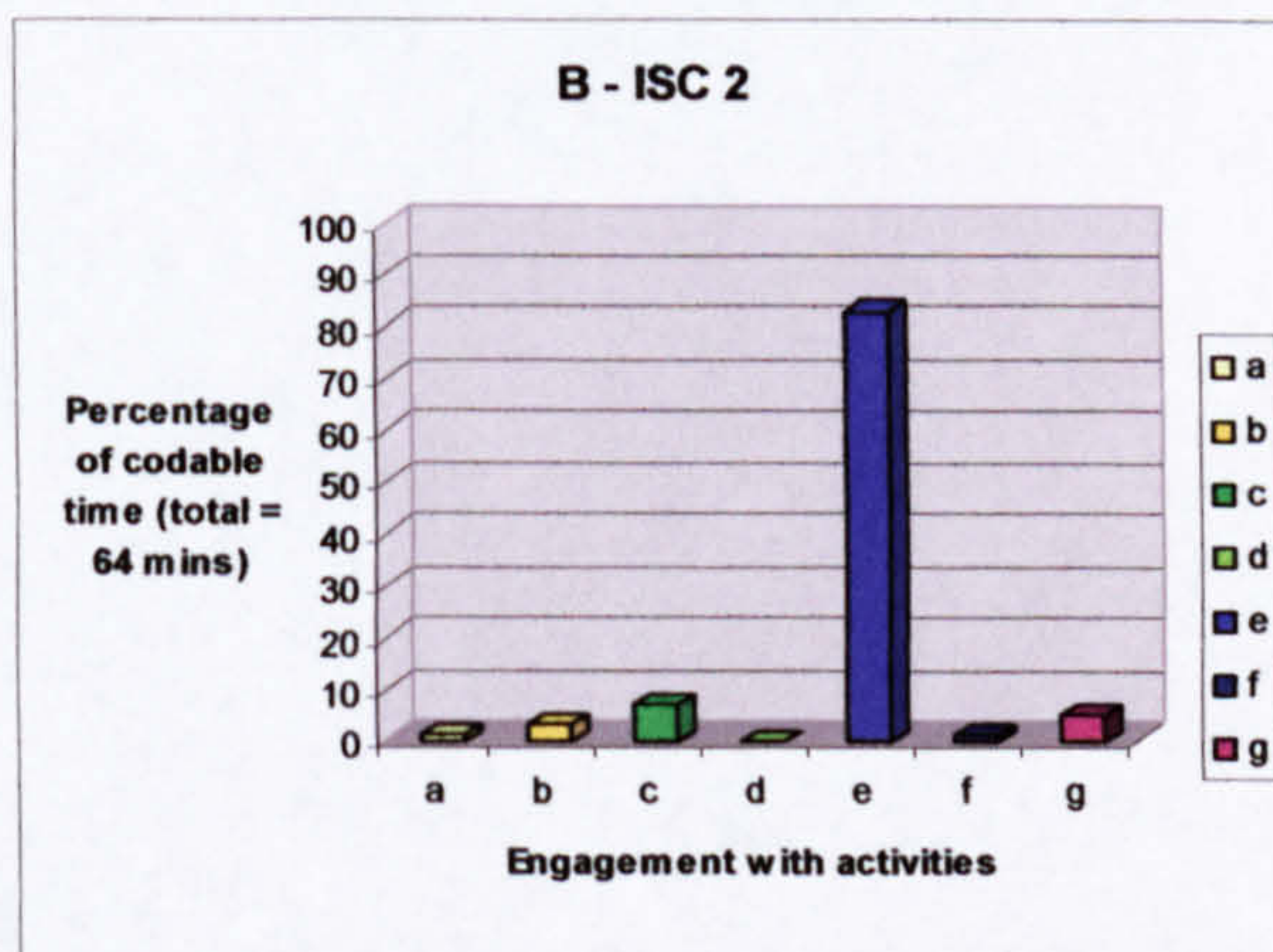
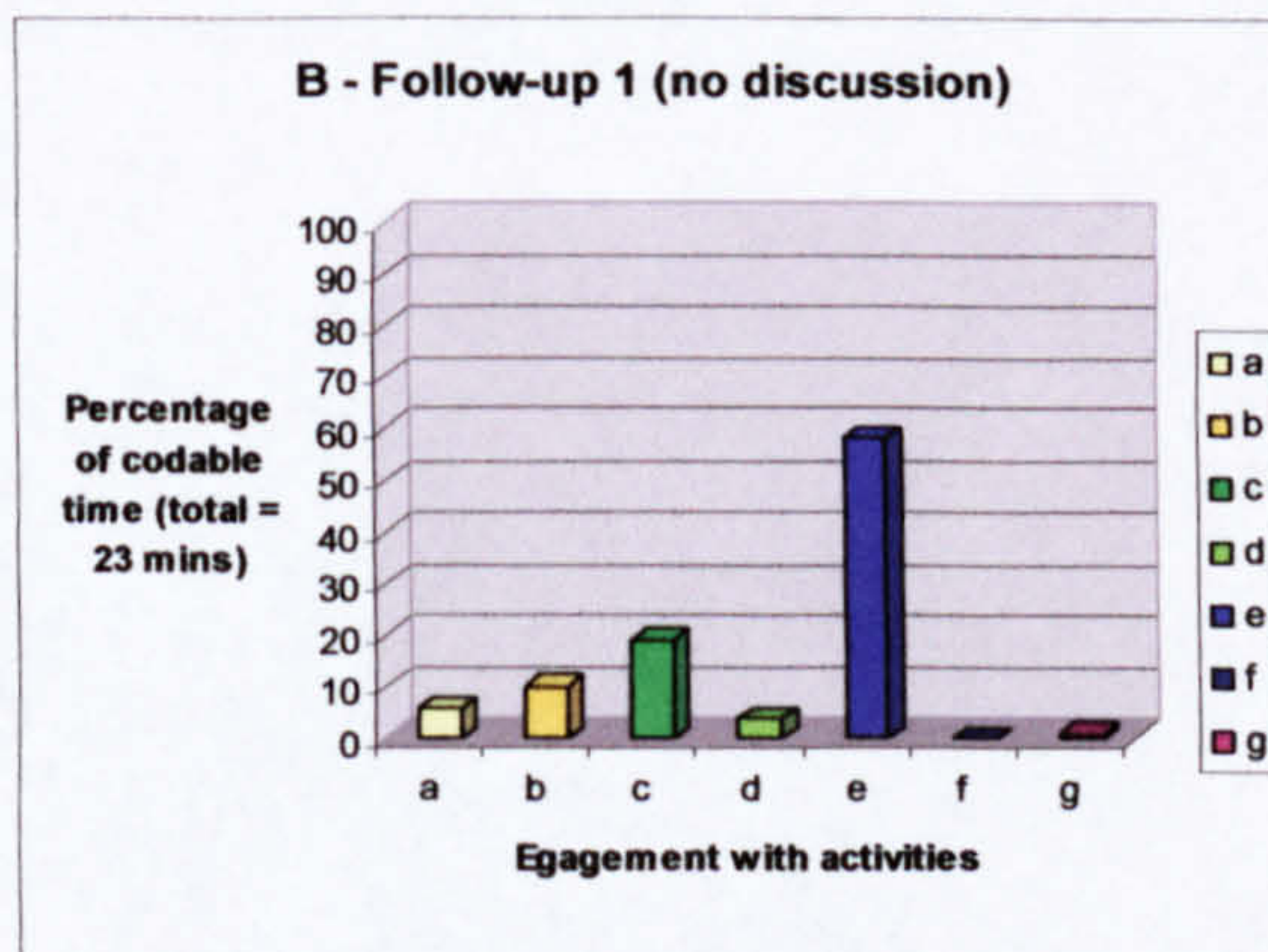
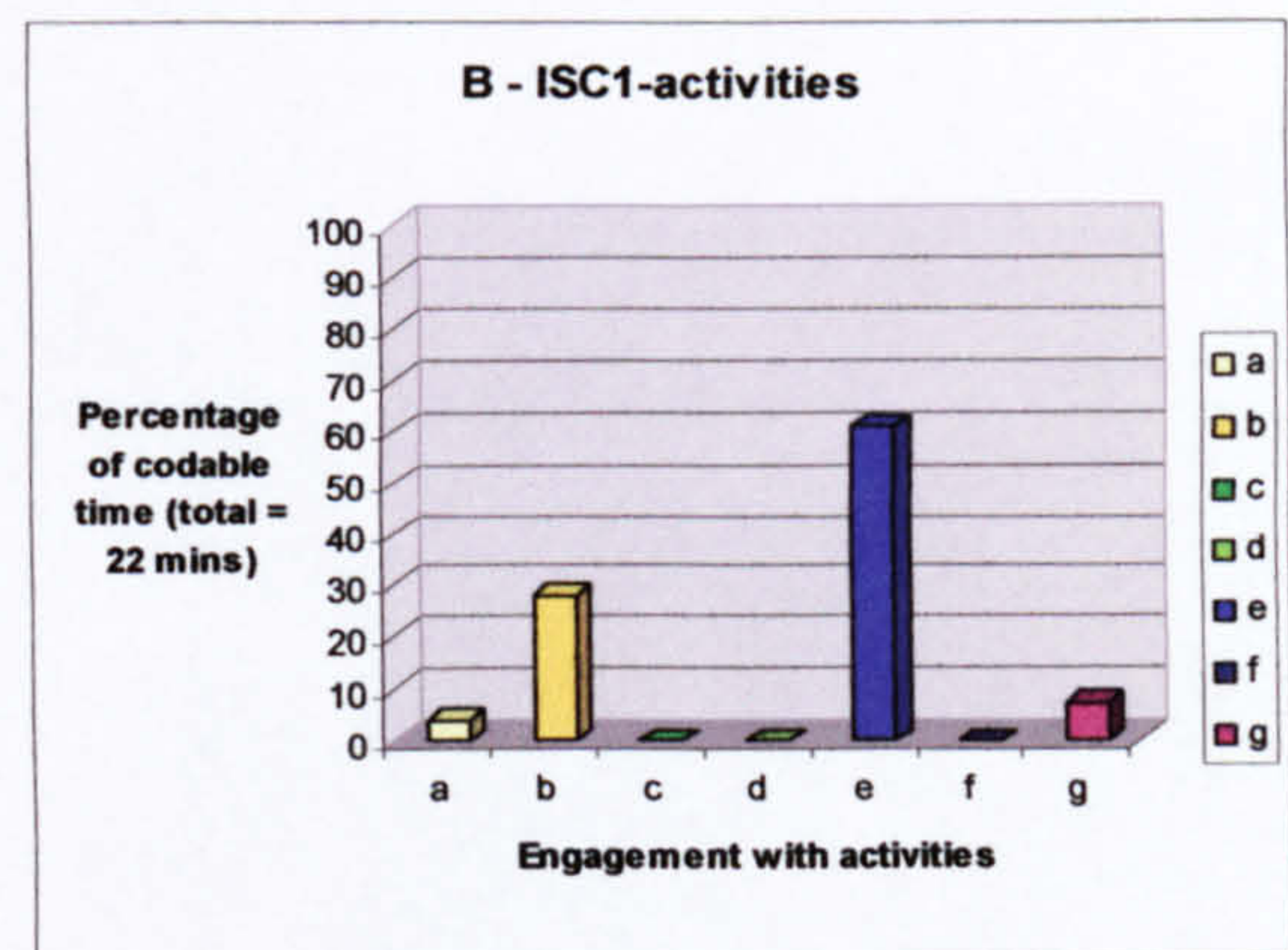
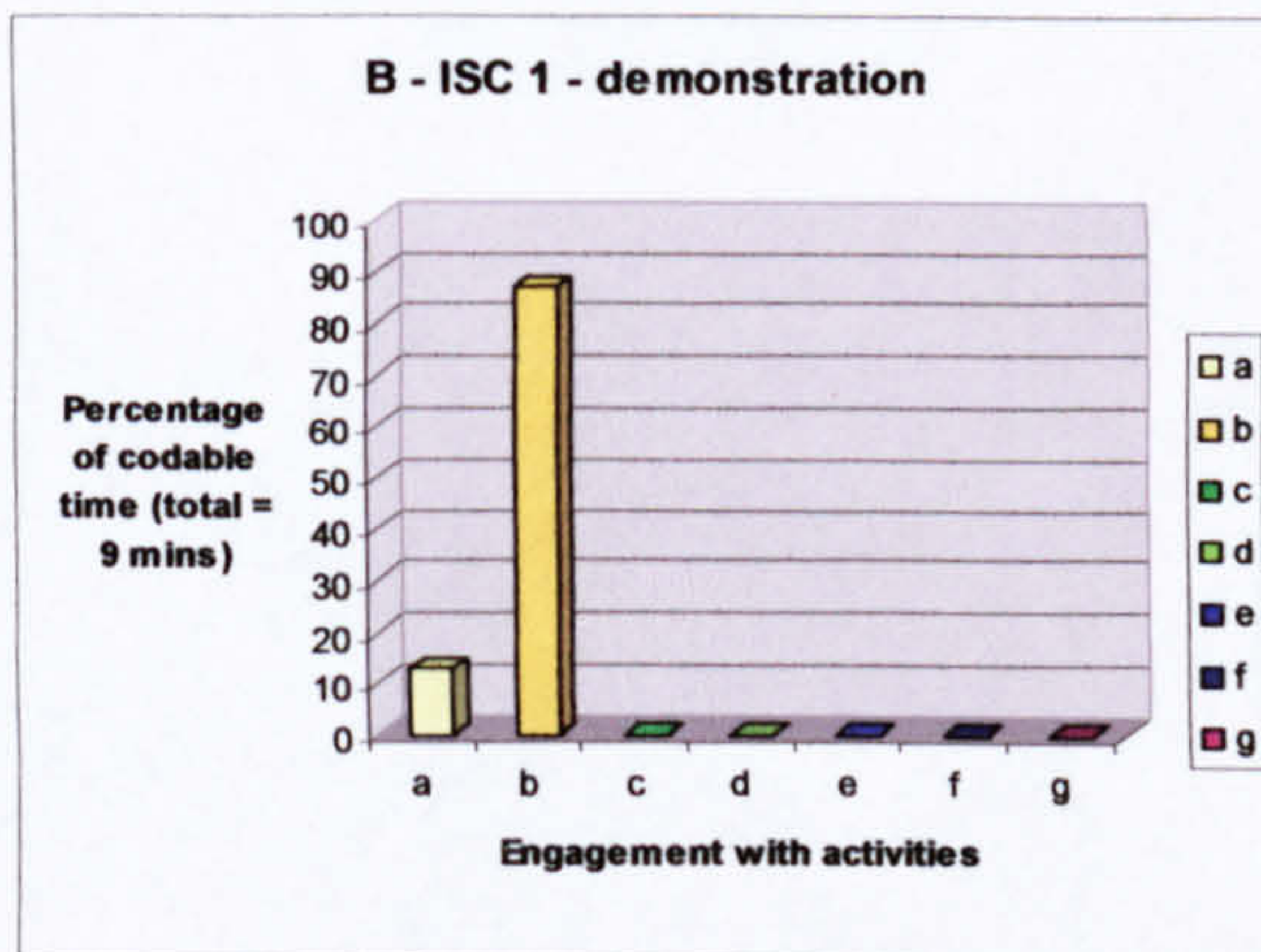
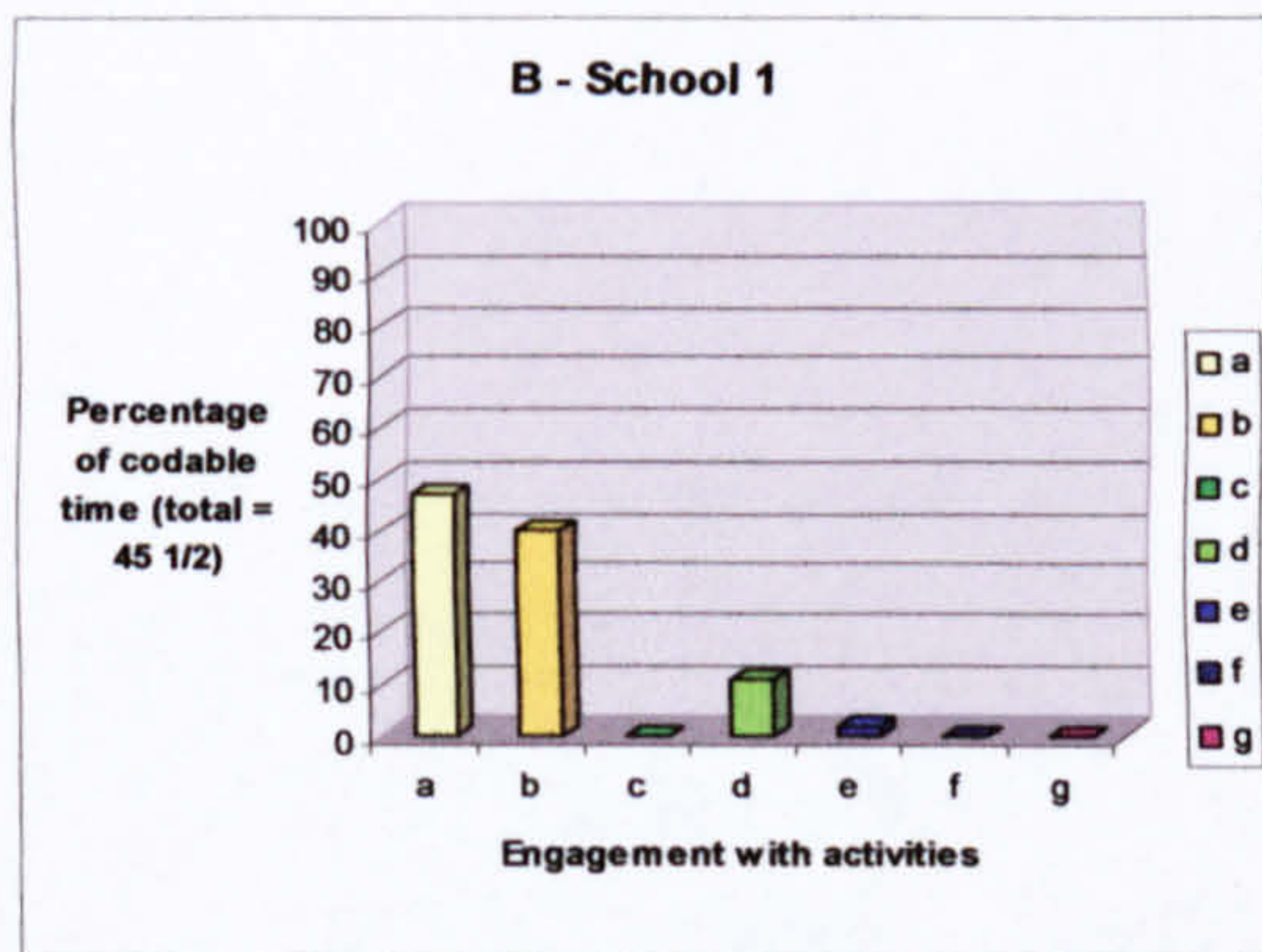
Karen



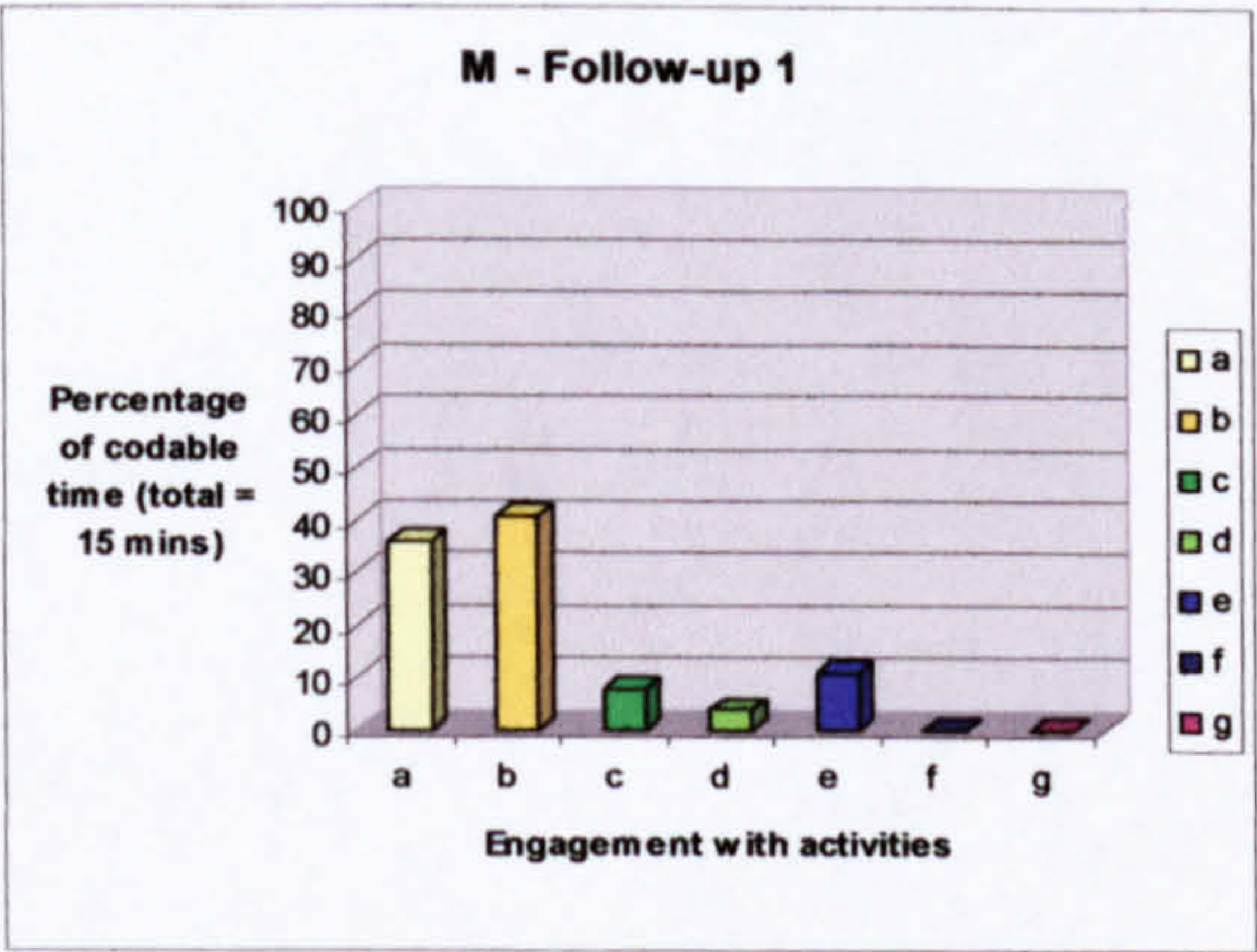
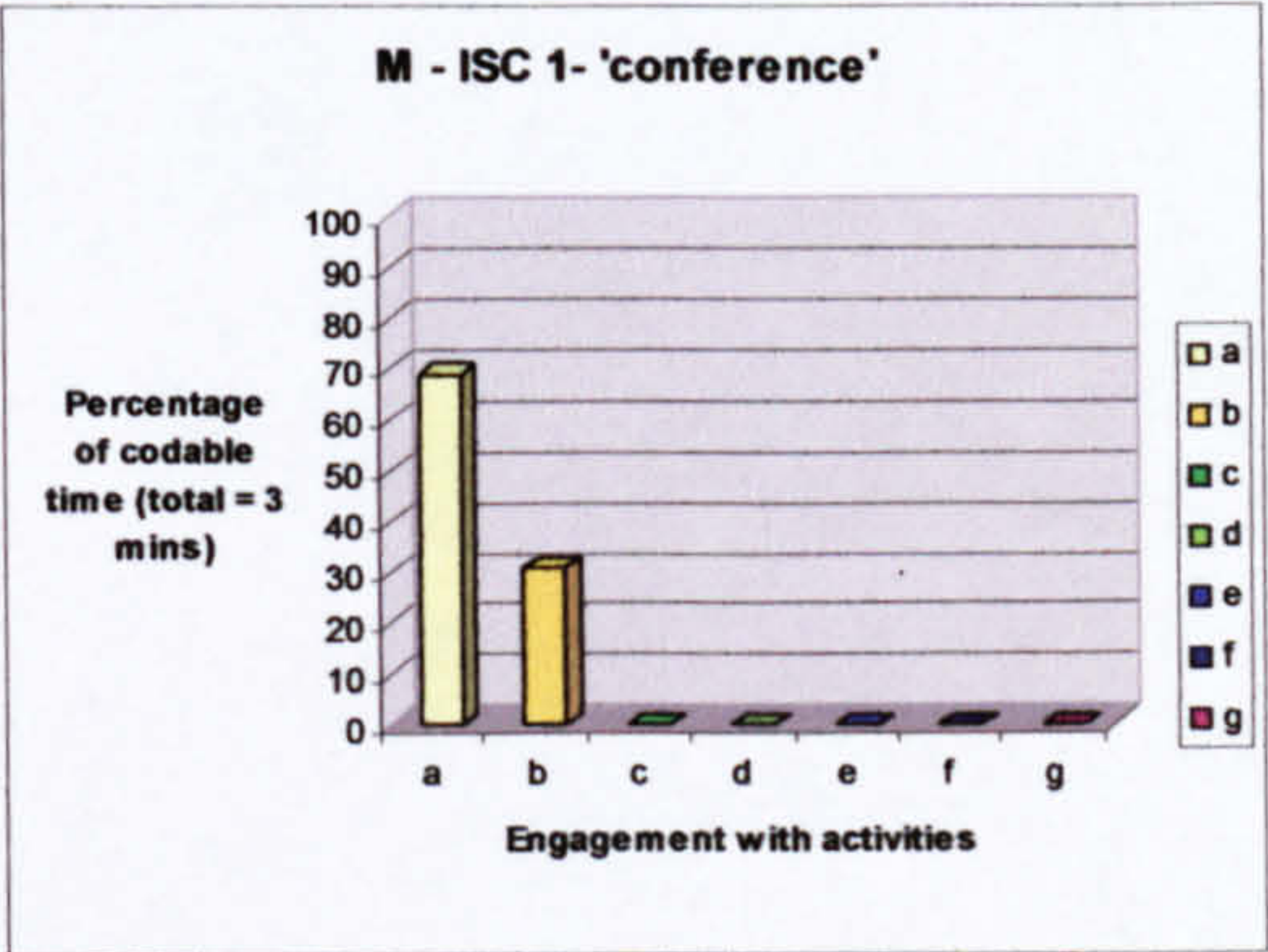
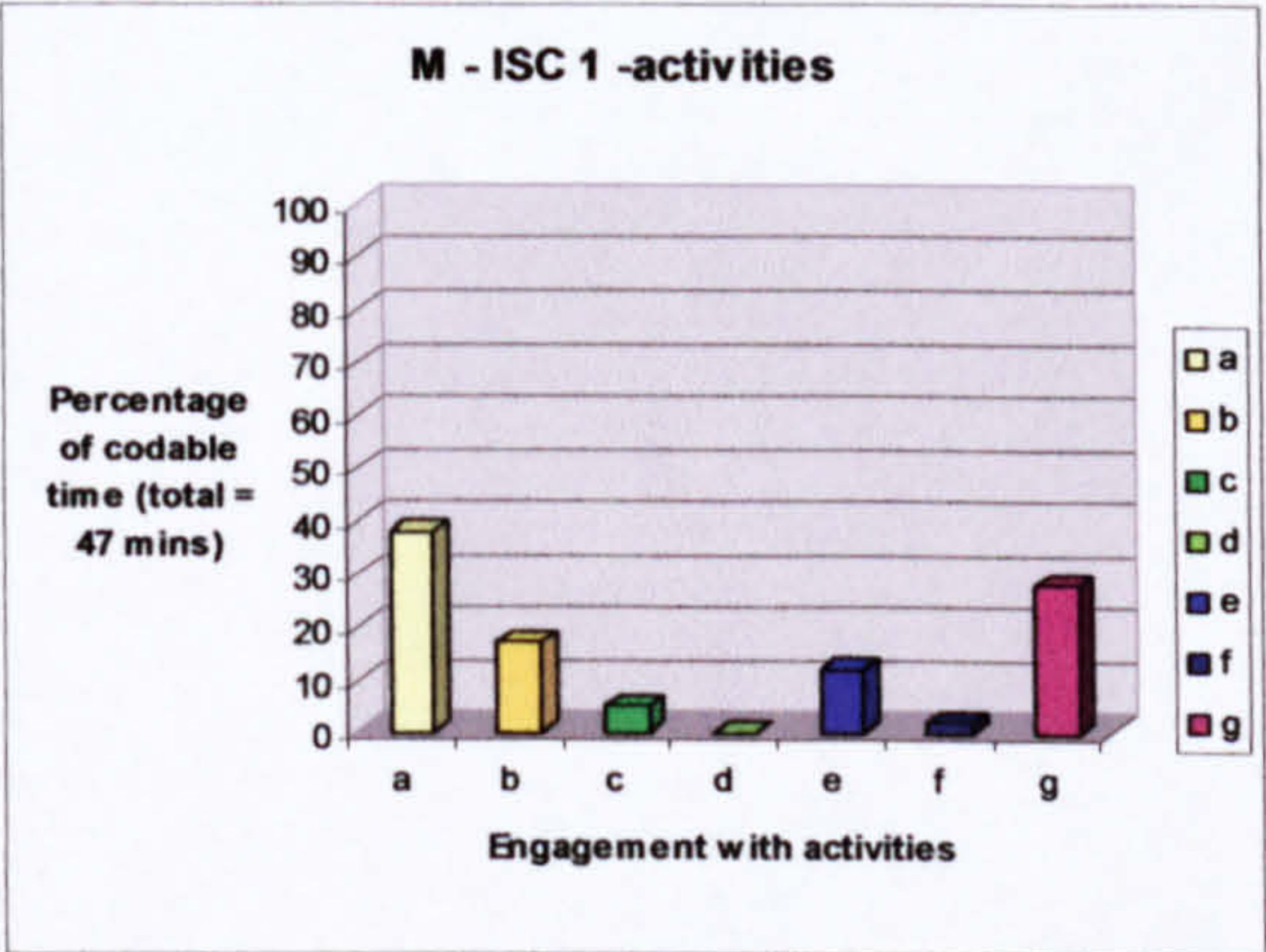
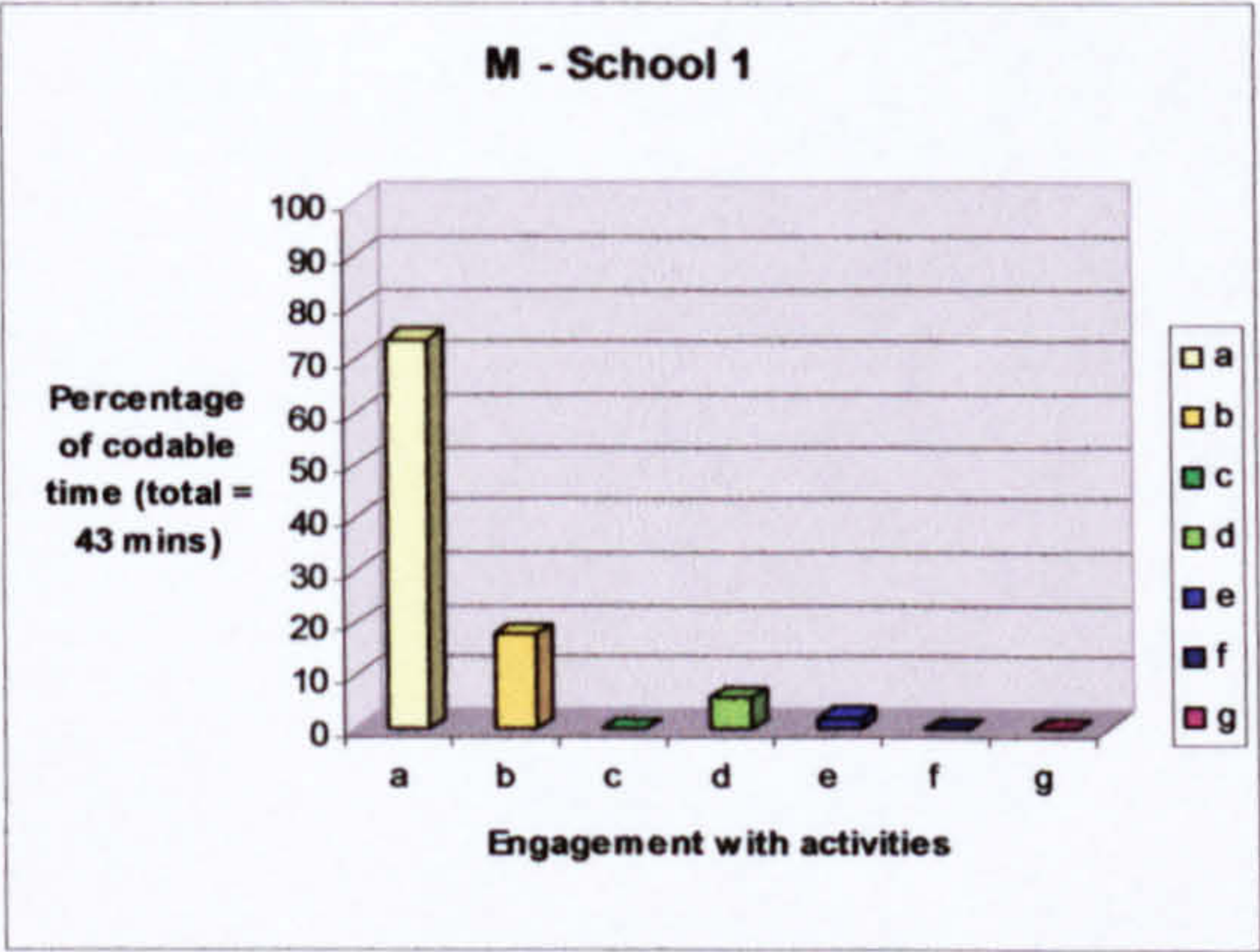


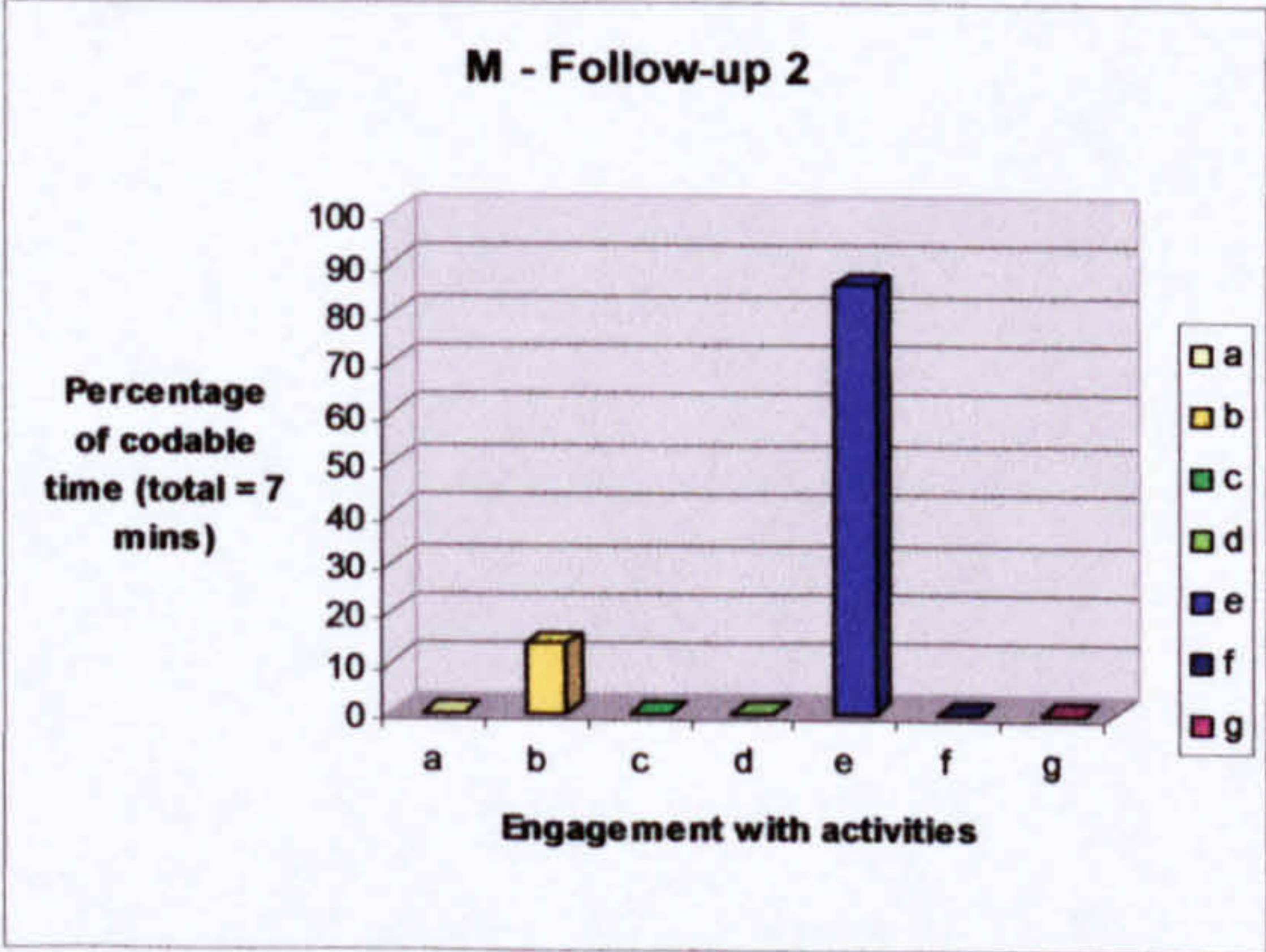
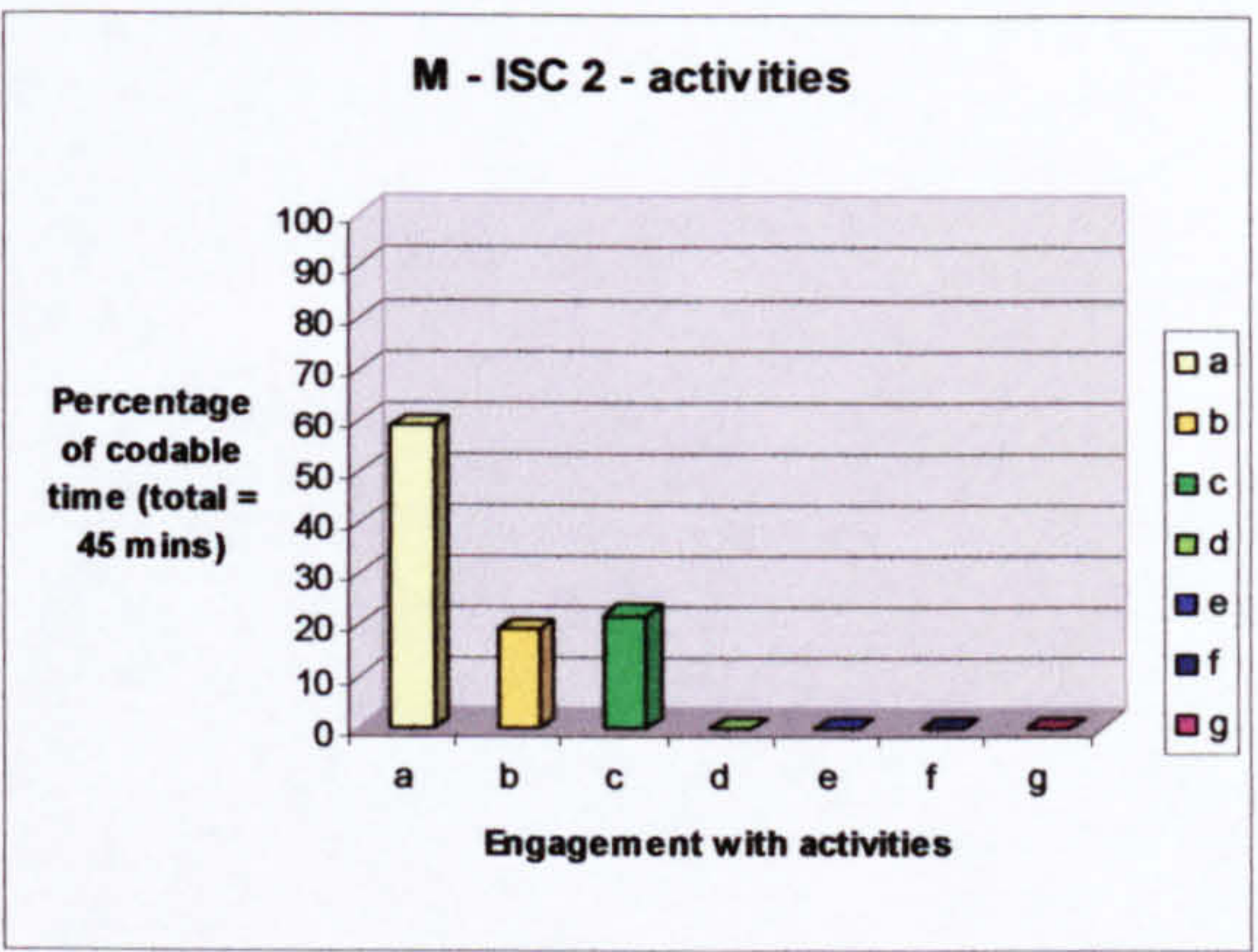
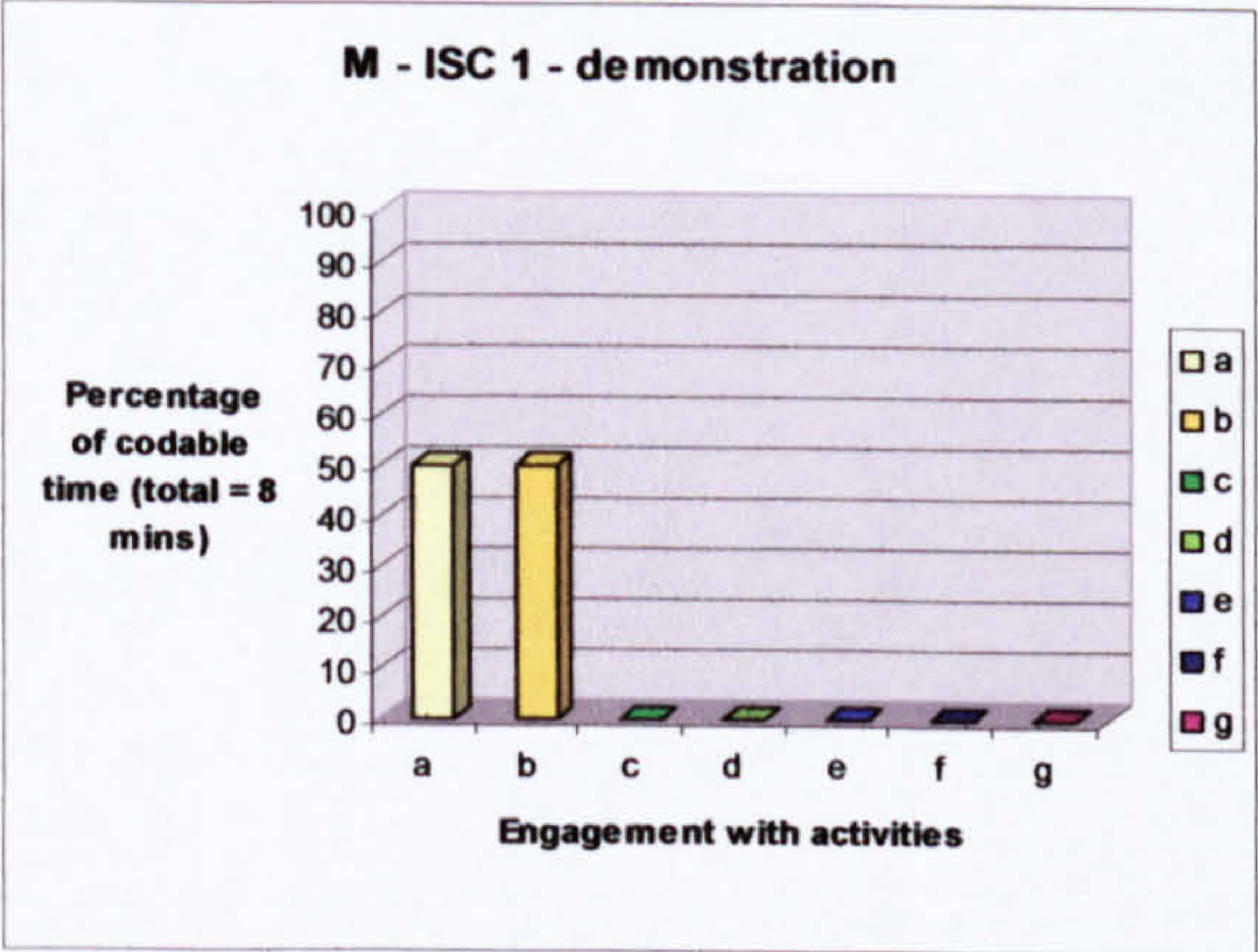
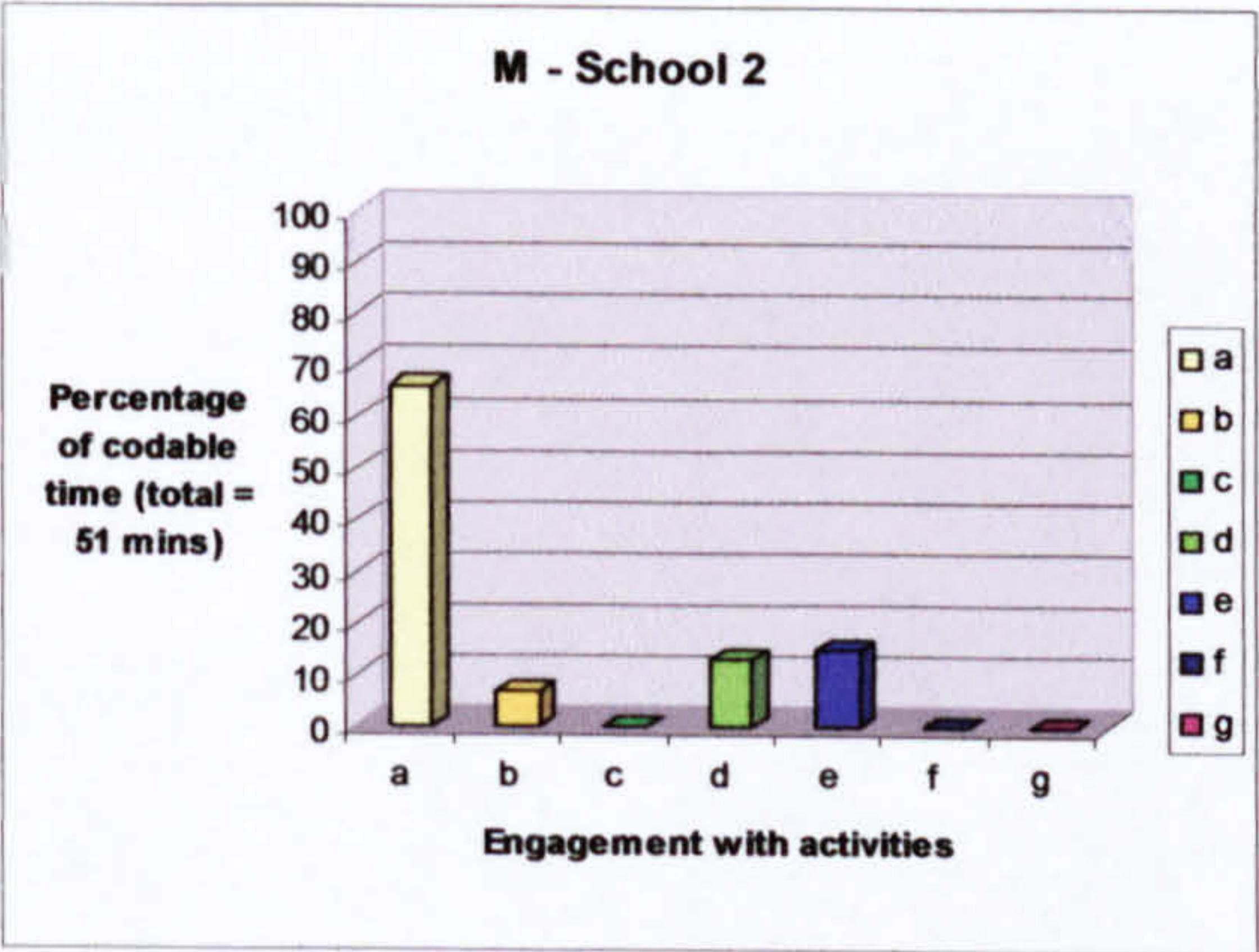


Bill



Michael





4.5.2 Summary of findings in relation to the research questions posed in the descriptive/exploratory phase of the research

This section summarises the main findings from the descriptive/exploratory phase of the research in relation to the questions set out in Chapter 3. Questions and hypotheses relating to the explanatory phase which emerged from this data are reported. The way in which the hypotheses evolved during the explanatory phase will be discussed in the next chapter.

All findings summarised here relate to the initial broad question:

- How do students with severe learning difficulties respond to visits to a small interactive science centre?

and the two further overarching questions:

- How did these students respond to activities similar to those at the ISC but in their usual educational settings 2-6 weeks after the visit?
- How did these students respond to a number of their usual sessions in school or college?

Data gathered from all three types of session (ISC visits, follow-up sessions and school or college sessions) were used to explore more detailed questions in the descriptive/exploratory phase of the research as they emerged. The following summarises the findings in relation to these descriptive questions.

Engagement and concentration

A number of questions were posed in relation to students' engagement, initially in relation to ISC sessions:

- Were these students actively engaged during visits to the ISC?

Then in relation to all sessions:

- What types of engagement with activities could be observed?
- In what proportions?
- What preceded sequences coded as 'investigation/exploration'?
- Under what circumstances were these students most actively engaged in any of the sessions observed?

- **Were these students actively engaged during visits to the ISC?**

There was, of course, considerable individual variation but it can be seen from the colour-coded charts (Appendix V) and the bar graphs presented above that all students showed high levels of active involvement with activities at the ISC (codes b-g indicate clear interest, c-g active involvement). Students who had been described by their teachers as lacking in concentration at times showed astonishing persistence, often in the face of repeated failure, to achieve goals they had clearly set themselves: Karen's teacher had said of her that '*she doesn't have very good concentration*' and that '*sometimes in a structured environment if she can't do something she might have a little tantrum rather than persevere*', but at the ISC, working to a goal of her own choosing, it was Karen's perseverance that stood out; for example trying to stick sellotape onto a car, something that was clearly physically difficult for her, she showed no frustration or sign of giving up at repeated failure.

Alan, who was also described as having a short attention span, again showed focused attention in the ISC and, for example at the Tilting Gutter, no frustration despite frequently not achieving goal he had set himself. Bill had been said to be hard to motivate but this was certainly not the case at the ISC where he was rarely disengaged from the activities. Likewise, Michael's teacher had said of him that he was rarely motivated and that he needed someone with him to do things '*workwise*' or he '*just stops*'. His involvement with the activities at the ISC was more variable than the others as, particularly on his second visit, he frequently sat and 'twiddled' a piece of string or a tape measure when allowed to do so by school staff. However, on his first visit he had shown how keenly motivated he could be, for instance by the Wind Tunnel, and then was playful, exploratory and innovative. Gemma was motivated once left to herself on her first visit and throughout subsequent visits. Only Michael and Jackie were less actively engaged on their second visits but had shown how motivated they could be on the previous visit.

- **What types of engagement with activities could be observed?**
- **In what proportions?**

The following summarises the findings regarding the different types and proportions of engaged activity in all sessions. Possible reasons for differences observed between settings or between different sections of sessions are discussed in Chapter 5. Again the colour-coded charts (Appendix V) give an at-a-glance summary of the sessions and the bar graphs show the proportion of time spent in each type of engagement for the five main participants.

Attention not focused on activity (code 'a') or not obviously focused (code 'a/b'):

Instances where students' attention was very clearly 'elsewhere' – that is focused on something other than a particular activity (code 'a') – were rare at the ISC and during the active parts of follow-up sessions. Often in language-based sessions (or parts of sessions), it was not possible to tell for certain whether or not students were listening. Where they were not looking at the speaker (often looking down at the table or the floor) and showing no particular interest in what was being said, these sections were coded 'a/b'. Sequences coded 'a/b' were common during discussion in the ISC or follow-up sessions and account for large sections of school or college sessions including the first (language-based) half of the Christmas card-making session and the session in the science laboratory, which in fact included very little practical activity. Scrutiny of the colour charts and bar graphs also revealed a certain percentage of time coded 'a' or 'a/b' – unfocused activity – during *active* parts of ISC sessions; these episodes are further explored below.

Clear interest but no active involvement (code 'b'):

During language-based sessions in school or college some students (Gemma, Karen, and Louise to varying degrees) showed interest in what was being said and a willingness to participate in discussion, putting their hands up to answer questions. Others (Alan, Richard, Bill and Jackie) rarely showed interest during discussion in school or college and participated only if specifically called on to answer a question. At the ISC most of the students, and most obviously Karen and Bill, showed active interest when the activities were being introduced. Karen showed more interest than

the others in discussion following visits or prior to follow-up sessions, using sign, mime and demonstration to supplement language. Bill showed some interest during discussions at the ISC or before follow-up activities, looking at each speaker in turn. Others, particularly Alan and, in the first year of the study, Gemma, tended to avoid participation, looking down when a question was asked. During active sections of ISC visits some of the students watched others briefly but most moved very quickly to active involvement; only Jackie on her second visit spent more time watching than participating, although with apparent interest.

Playful behaviour (code 'c'):

The definition of play used included Bruner et al's (1976) combinatorial play – trying things out, in different ways, with no particular aim – as well as more obvious 'playing about' accompanied by laughter, the enjoyment of sensations or make-believe play. Even using this extended definition, behaviour that could confidently be coded as play was not frequent: make-believe play was very rare and 'playing about' accompanied by hilarity, although more frequent, was still quite unusual. Some students tried out the equipment but most moved quickly to setting themselves a goal. Some clearly playful sequences were recorded: many of the students showed enjoyment of sensations such as the wind from the wind tunnel, deliberately placing themselves so they could feel it; Bill spent a long time playing with another student with the Electromagnet, each trying to pull the other's iron bar out with a metal spoon and laughing as they did so. Michael lifted a fellow pupil to see what would happen to her dress in the wind from the Wind Tunnel in a way that was certainly playful but was not recorded on camera so not included. Some sequences coded 'exploration' contained playful elements,

including much of Michael's activity at the Wind Tunnel. Playful episodes were slightly more common for younger students and the age of most of the students may have been a factor. It could also be that these students were not accustomed to activities in school time being playful; even the youngest spent most of their time sitting and listening in the sessions observed in school and no behaviour was coded 'play' for any of the sessions filmed in school or college. A 'free-play' session for the youngest group was observed (not filmed) but the teacher made it clear that such sessions took place only on Friday afternoons (field notes). The relative lack of behaviour that could be considered play in the ISC may also have related to the way in which some of the activities were introduced, with suggestions such as '*you could see if you can get the ball into the bucket*'. In this case I, as organiser of the visits, may have created the situation, on the other hand the same type of phrase was used for mainstream visits and more playful behaviour was observed during these. In the present study enjoyment of activities was very clear but usually shown when working to a self-imposed goal, indeed it was particularly evident when the goal was achieved, often accompanied by a look or gesture of triumph.

Following instructions (code 'd'):

Staff used a high level of direct instruction in the school and college sessions that were recorded and from time to time in earlier sessions in the ISC; it was more explicitly requested in later visits that students should be left to do as they wished. Gemma was very much directed by her teacher during her first visit, the following year it was she who gave instructions to both Alan and Richard. Alan and Richard tended to be directed by both college staff and fellow-students. The semi-

structured interviews with the participants' teachers made it clear that they all considered it necessary to be directive in school or college; the approaches used in these settings are discussed later. ISC staff deliberately avoided this kind of direction and in later sessions it was made clear to school/college staff that the aim was for the students to be allowed to do as they wished, so in some ways the contrast was unsurprising, what was more surprising was the way in which students actively avoided direction in the ISC.

Working independently or in collaboration to a goal (code 'e'):

For this coding goals could be individual or shared but were almost always voluntarily undertaken and usually self-imposed. This type of activity was very common during active sessions at the ISC and follow-up, rare during school or college sessions; in college Gemma carried out practical activities independently once she had been told what to do, Karen in the second session filmed in school got on with writing on a worksheet on her own but only when told she would stay in at lunchtime if it was not completed. It could be said that the type of activities students were being asked to do in school or college did not lend themselves to this type of active engagement but it was rarely observed even in the active sessions filmed in these settings (making Christmas cards, potting up tomatoes or working in the science laboratory). Often at the ISC or during follow-up sessions the students' goals were evident from their delight when these were achieved, on the other hand signs of frustration when a goal was not achieved were very rare.

Making adjustments or adaptations to achieve a goal (code 'f'):

Unsurprisingly the extent to which adjustments were made to achieve a goal varied from student to student: Gemma appeared content to set herself a very simple goal and repeat the same actions to achieve it (for example placing a ball by hand into the gutter, rather than using the bucket and pulleys to get it there). Alan only made adaptations to achieve a goal when working alone at the ISC or during follow-up sessions; on his first visit to the ISC he seemed to need considerable time to move on to this stage but at the follow-up session did so immediately. Karen made these sort of adaptations and adjustments from the start. No sequences were coded 'f' in school or college.

Again it could be said that activities in the students' usual settings did not lend themselves to this type of activity; most were language-based and involved a high level of sitting and listening, even for the youngest pupils. However, this raises the question of why this was so, given the students' language levels stated in their records. A number of authors have pointed out the dominance of language-based learning in education (Gardner 1983, Hodgkin 1985, Moyles 2005). Learning to sit still and listen was also seen as 'socialisation' (see teacher interviews). Even potentially active sessions in school or college (making Christmas cards or working in the science laboratory) included a high proportion of listening and all activity was closely directed. There may have been particular reasons for this; the items produced were to be sold in the first instance, lighted Bunsen burners posed a particular safety hazard in the second. However the teachers did not suggest that these sessions were out of the ordinary. The only completely active session - potting up tomato plants - was again very directive; here too the product was to

be sold. Teacher 1 remarked of approaches in college, '*Problem-solving doesn't really come into it.*'

Investigation/Exploration (code 'g'):

Behaviour coded as investigation or exploration ('g') was relatively rare even in ISC or follow-up sessions as a stringent definition of this code was used in order to distinguish it from others, particularly combinatorial play (see Appendix II). Sequences were only coded 'investigation/exploration' if there was a clear intention to find out more: either to investigate cause and effect or to systematically explore the possibilities of the equipment. Again no sequences were coded in this way in school or college.

- **What preceded sequences coded as 'investigation/exploration'?**

Small-scale sequential analysis was used to look more closely at what led up to exploration in the ISC (reported in section 4.4.1) and suggested two different types of exploration: one relating to a surprise or a puzzle, leading to investigation designed to find out about cause and effect (why did that happen?) the other simply an exploration of the possibilities of the equipment (what happens if ..?).

- **Under what circumstances were these students most actively engaged in any of the sessions observed?**

It was clear from the start that the degree to which students engaged with activities was very different in different situations; what was less clear initially, however, was the circumstances under which this was taking place. Informal discussion with the teachers had suggested that there was a considerable difference between students'

behaviour in their usual educational settings and at the ISC and filming of school or college sessions appeared at first to confirm this. One suggestion for this difference was the novelty of a trip out of school (see teacher interviews); however engagement levels frequently turned out to be as high, or even higher, in the follow-up sessions which took place in the students' usual educational setting, albeit with activities brought in by an outsider (see colour charts Appendix V and bar graphs). It is only possible to speculate about why this was so as these sessions were not the main focus of the research. They took place in more familiar surroundings with smaller groups and it may even have been the fact that the experience was *less* novel that often made for higher levels of concentration. Approaches used were very similar to those in the ISC, however, and the fact that groups were smaller permitted an even higher degree of choice and control for students as there was not the same need to balance the needs and wishes of one individual against those of another and staff were more available to provide scaffolding when required.

The use of theoretical coding and the coloured-coded time-lines showed that the contrast was not a simple one between the students' usual activities at school or college and those taking place at the ISC or in follow-up sessions: there were also times when students became much less engaged *within* ISC or follow-up sessions. Engagement levels appeared much lower during the discussion session at the end of visits to the science centre, and also during discussion at the start of follow-up sessions. When quantitative analysis was carried out the percentage of time spent in each type of behaviour was calculated separately for the discussion sections of ISC visits and follow-up sessions; the bar graphs clearly show the contrast

between these and the active sections. These observations led to the hypothesis discussed in the following chapter that levels and types of engagement related not so much to the settings themselves but to pedagogical factors within the settings. Initially modality of presentation appeared to be the main factor, whether or not sessions were language-based, however, even within the *active* sections of ISC visits there were times when students were considerably less engaged and in the one wholly practical session observed in college Alan, at least, is frequently entirely disengaged from the activity (see colour charts and bar graphs). These instances seemed to relate to choice and control more often than input mode as will be further explored in Chapter 5.

The students' responses to other people

During the preliminary stages of the research, staff from the students' school or college had commented that the science centre seemed to encourage communication and co-operation between students.. However, as observations continued the picture was seen to be more complex, raising a further question:

- **How do these students respond to other people during sessions observed?**

Some real co-operation and collaboration was apparent, including where avoided previously, such as the game between Bill and John described above.

Nevertheless, when given the choice, students frequently avoided working with peers at the ISC: during Karen's first visit she resisted attempts by other students to join her at activities; fellow-students moved away from Bill on his first visit and his teacher said they were scared of him. On the other hand students frequently sought admiration for achievements, usually from staff, occasionally

from peers, signalling 'look at me' by word or gesture. They usually accepted and sometimes requested, help, if they were having physical difficulties with the equipment or it was hard to achieve a goal alone, but avoided staff direction and input designed to question or teach. Karen and Gemma, particularly on her first visit, very deliberately avoided attempts by staff to explain or direct. The second small-scale sequential analysis (reported in Section 4.4.2) suggested that contingent scaffolding, leaving the student in control, was welcomed while direction or instruction that took control away from the student tended to reduce engagement. These findings were further explored in the explanatory phase of the research.

Independence

An aspect of interactions with others that was of particular interest was the degree of independence shown by these students, again something remarked on by their teachers, leading to the further question:

- **To what extent do these students take independent initiative in the different sessions observed?**

The students were invited to do what they liked at the ISC and some were not only willing and able to take initiative but showed a strong desire to do so. Karen, from the start, knew exactly what she wanted to do and avoided being directed; on one occasion she briefly watched another student at the Wind Tunnel with an LSA but, when the LSA tried to explain what was happening and involve her, she walked away. A short time later, when she saw that there was no one at the Wind Tunnel she walked swiftly back and remained there for several minutes, carrying

out the activity on her own with enthusiasm, clear understanding and perseverance in the face of difficulties. Bill too, from his first visit, moved from activity to activity, carrying them out with enthusiasm and apparent understanding and with a complete disregard for whether or not others were already there, often causing them to move out of his way. It was only the following year that he showed an ability to enjoy collaboration. For both students this contrasted with their behaviour at school in the science laboratory and, for Karen, the second school session too, when Bill was absent.

For others independent and engaged behaviour, even at the ISC, appeared to depend very much on the circumstances: Gemma on her first visit showed a strong dislike of being told what to do; she very reluctantly followed her teacher to the Breathing Skeleton but then ducked (literally) away from the teacher's verbal explanations of how it breathed. She went by herself to the Circuits where she was immediately actively engaged for some time until a helper from the ISC tried to explain the meter to her when she appeared to lose interest. The second year that Gemma visited, she appeared much more confident and her teacher commented on her development in the intervening time. This time she not only avoided being directed by others but showed a liking for directing and teaching her fellow students, particularly Alan and Richard. She gave them step by step instructions and praised them if they did things 'right', speaking to them as if they were small children (or perhaps as she has been spoken to herself); if they tried to move away she called them back. Her behaviour was very similar during her third visit to the ISC and during the second and third follow-up sessions.

Alan's behaviour showed the strongest contrast between college and ISC/follow-up sessions but also within ISC or follow-up sessions. He took very little part in any of the language-based parts of sessions, whether in college or the ISC, speaking only if asked a direct question and then very little. In activity-based sections of college and ISC sessions, fellow-students as well as staff tended to direct. He did not resist this, and followed instructions step by step but stopped, stared at the floor or ceiling, or adjusted his clothes, as soon as the instructions stopped, even in the ISC. Thus he conformed to his teacher's description of him as doing nothing without being told. However, as soon as he was encouraged to go to an activity on his own (and Gemma was encouraged to allow him to do so) his behaviour was quite different. On his first visit to the ISC having followed Sam's instructions at the Tilting Gutter, as soon as he was on his own he operated it with confidence and enthusiasm, seeming very sure of what he wanted to do and how to achieve it. It took him some time to achieve his goal but he remained absorbed in what he was doing, not becoming frustrated or discouraged by repeated failures. Having time to do things in his own way seemed important for Alan as well as being given the freedom to do things on his own.

All of the students in fact showed themselves willing and able to do things independently although for some this was less frequent than others.

Like Alan, Richard showed more initiative when on his own but often seemed content to remain in others' shadows, particularly Gemma's, and to carry out their instructions. On Jackie's first visit she spent some time plugging in leads to make a spinner spin or a light come on, showing great delight at being in control. This involved and independent activity was not really seen again, although she

watched the others with great interest. Michael, Louise and Alex all showed themselves capable of taking independent initiative when given the chance, although Michael did not appear motivated by the activities at the ISC on his second visit.

Understanding, recall and transfer

A number of subsidiary questions were posed in relation to the students' understanding and recall of the activities in the ISC and their ability to use what they remembered in a different setting and with slightly different equipment:

- What evidence is there of these students' understanding of any of the concepts involved in activities at the ISC during a visit?
- What evidence is there that these students recall what they had done during the visit to the ISC?
- What evidence is there that these students are able transfer what had been learnt at the ISC to a slightly different situation?

Evidence of understanding

Discussion with the students in the study during or after sessions at the ISC proved inadequate as a means of gauging their understanding, as did discussion prior to follow-up activities. The students rarely responded except to direct (closed) questions, and then only to factual rather than explanatory questions. Some were keen to *show* what they had done during the discussion session at the end of a visit (Karen was the most eager to do this). School/college staff tended to discourage students from getting up during discussion sessions at the end of early visits, perhaps because this was discouraged in school or because they felt it was

inappropriate behaviour in the ISC. When it was made explicit that this was welcomed, students were able to give more information but still only in answer to '*what?*' questions. Some used signing or mime to supplement words to describe *what* they remembered (again, of the students in the study, only Karen volunteered this without being asked a specific question). The students almost never responded to verbal questions designed to gauge understanding of concepts, such as '*Why* do you think something happened?'. Observation, however, had provided considerable evidence of understanding of concepts and mental models of what was happening.

Making adjustments to achieve a goal (code 'f') implies a certain understanding, even an adjustment as apparently simple as altering the angle of the Tilting Gutter, necessitates an understanding, however tacit, of the cause and effect involved in aiming the ball into the bucket. Adjusting the position of the bucket (much less common) means thinking about cause and effect separated by both time and distance. The contrast between students was revealing: Gemma rarely made adjustments and seemed content to set herself a very simple goal, repeating a simple action and rarely varying it, despite the fact that she spent a great deal of time telling Alan and Richard what to do. In contrast Karen made adaptations to what she was doing throughout and Alan did so when left alone, although on his first visit it took him some time to move on to doing this.

Evidence of understanding of cause and effect depended not only on the individual student but also on the particular activity. Karen experimented with the Motion Detector, varying the type and speed of her movement in front of the ultrasonic beam, intently watching the effect her movements were producing on the

time/distance graph on the computer screen. She even appeared to understand that by standing still she could produce a straight line, since, having done so and closely watched the effect, she exclaimed '*Yes!*' and raised her arms in triumph. Alan and Richard on the other hand watched the screen but did not move in front of the beam, even when encouraged to do so. Most of the students showed a clear understanding that by hitting the Thump Wave drum they were producing a current of air that was moving the clown's shirt but Jackie continuously hit the drum without looking at the clown and it seemed possible that, for her, the effect was too far removed from the cause in both distance and time.

The ability to predict and therefore to see the world as a predictable place implies a mental model, a model that is at least functional if not necessarily totally accurate (Gentner and Stevens 1983): Gemma for example mimed knocking the first in a line of dominoes before she actually did so. It is also vital for problem-solving: when Gemma knocked the first of the fixed dominoes on a sloping board, nothing happened; she was able to work out that the board has been placed the wrong way round so the hinges were preventing them from falling. The surprise, described above, that in some cases led to exploration also depends on having a mental model that is then contravened: metal objects are pulled into the Electromagnet, why is a bar made of lead not pulled in? Cars run down a slope, why is this one standing still?

Humour too can demonstrate a mental model: Alan pretended that the Electromagnet was not working when in fact he had switched it off, laughing up at the helper while he jiggled a piece of metal in it, showing by mime that it wasn't

being pulled in, then laughingly turning the magnet on when she asked if something was wrong, clearly showing that he understood how it worked.

Recall and transfer

The students showed clear recall in the follow-up sessions two to six weeks after visits and some evidence of ability to transfer what had been done at the science centre to a different setting and slightly different activities. Again, contrasts between the students in the study were illuminating: the difficulty experienced by one highlighting the extent to which others were able to do this. At the ISC Jackie had hugely enjoyed plugging leads in to make a spinner spin or a light come on. During the follow-up session she was presented with equipment with wires that needed to be touched together to make the light come on; she persistently tried to plug the wire into a hole in the box even after repeated demonstration. Jackie demonstrated recall but great difficulty adapting. Other students seemed to start in follow-up sessions where they had left off in the ISC, although the equipment was somewhat different; Karen and Alan were striking in this respect. Karen was able to adapt her memory of a set of pulleys high up on a huge metal structure to recreate these with wooden poles, circles of wood and ropes. Of course she may have had prior experience of pulleys in school but others in the same group were not able to do this. Alan had taken some time at the Tilting Gutter to think of adjusting the position of the bucket during his first ISC visit; during the follow-up session (three and a half weeks later) he not only adapted to the gutter being tied to a chair back but immediately adjusted the bucket. These instances were in strong contrast to the understanding and recall that the students were able to demonstrate verbally.

The question that stood out following the descriptive phase was:

- Why were these students' responses so different in different situations?

And related to this:

- What led to such high levels of independent, engaged activity in certain situations?

Two main propositions or hypotheses arising from the data and the descriptive phase of the study were explored with respect to these questions: these related to the environment itself and within this to the students' interactions with other people. The way in which these hypotheses evolved and were revised is detailed in Chapter 5.

CHAPTER 5: DISCUSSION

This chapter considers hypotheses grounded in the data relating to the questions posed in the explanatory phase of the research and examines them in relation to the findings and to the literature. Possible alternative explanations and issues relating to methodology are discussed, as well as implications for practice and for future research.

5.1 Evolving Hypotheses

Two principal questions emerged from the descriptive/exploratory phase of the research: Why were these students' responses so different in different situations? And related to this: What led to such high levels of independent, engaged activity in certain situations?

Two main propositions or hypotheses arising from the data and the descriptive phase of the study were explored with regard to these questions; these related to the environment itself and within this to the students' interactions with other people. The hypotheses needed to be revised as more data were collected and scrutinised, emphasising the need to code all material and take account of negative instances and alternative explanations. It was possible to explore some aspects of the hypotheses in greater detail with the use of quantitative analysis and sequential analysis. Other aspects were strongly suggested by the data and supported by the ongoing literature review but it was not possible within the scope of this research to examine them further.

Hypothesis 1

Informal discussion and interviews with the teachers had suggested that the students' responses were different in different settings - in the ISC compared to school or college - and this formed the basis of the initial hypothesis. One explanation put forward for this was the novelty of the trip out of school; in fact students frequently showed an even higher level of engagement during follow-up sessions, which took place in their usual settings, and, at times, lost concentration or involvement at the ISC. Quantitative analysis of the percentage of time spent at different levels and types of engaged activity, displayed as bar graphs in Section 4.5.1, showed a marked difference between language-based and active sections of ISC and follow-up sessions as well as between these and school or college sessions. This suggested that pedagogical factors were of more importance than the setting itself, in particular, it appeared, the modality of input, leading to the revised hypothesis that the degree of independent and engaged behaviour depended on whether sessions were language-based or whether they were multi-sensory and active.

This was retained as an important element in the students' engagement levels, however, it could not account for the fact that at times during activities at the ISC for some students engagement was reduced or that during practical sessions in school or college (the practical part of the Christmas card-making session, re-potting tomato plants or practical science in the laboratory) very little independent engaged activity was in evidence. Rather, this seemed to relate to whether or not the students were able to choose and have control over their activities. The question of 'locus of control' was developed in the second hypothesis.

Hypothesis 2

Within the learning situations observed, the role of other people was seen increasingly to be a very important influence on students' responses and to affect engagement with activities both positively and negatively. Initially it was hypothesised that students responded better to non-verbal than to verbal intervention from other people, particularly from staff. The second small-scale sequential analysis – reported in Section 4.4.2 - was used to look more closely at the effect of interactions with other people on engagement levels for the five main participants. In fact there was no obvious difference in behaviour following verbal as opposed to non-verbal interventions; however, degree of engagement with activities did appear to be affected by whether or not students remained in control during an interaction. This led to the revised hypothesis that engagement levels were strongly affected by whether or not interactions left students in control of an activity or whether this was perceived as an attempt to take over, usually in the form of direction, instruction or questioning (locus of control). The sequential analysis supported this view: where students had requested support or where just enough contingent scaffolding was offered to help them out of an evident difficulty, engagement levels remained unchanged or increased. Where intervention by other people took the form of direction or instruction, whether from staff or fellow-students, engagement levels were often significantly reduced.

These small-scale quantitative and sequential analyses cannot be seen as providing definitive explanations for differences in behaviour even for these particular students (see below for a discussion of possible alternative explanations and methodological issues). Nevertheless, with the literature, they support a view of the

importance of pedagogical elements of the learning situation, and of interactions between these (Murphy 1996), in influencing motivation and independent engaged activity, in particular the importance of modality of input and of choice and control. These are discussed below as are a number of other factors relating to the learning environment and the nature of the activities suggested by the data, with support from the literature, as being important in encouraging independent and engaged behaviour.

5.1.1 Exploration of the hypotheses in relation to the findings and to the literature

Choice and control

Choice and control are at the heart of the methods debate: in traditional behavioural approaches every step of the learning process is carefully controlled by the teacher. One of the main concerns raised about these methods was that they did not lead to independent behaviour (Byers 1994, Wood and Shears 1986) but rather that such control led to 'learned helplessness (Seligman 1975) and that this might even be encouraged, more or less unwittingly, in an attempt to make students' behaviour more socially acceptable (Griffiths 1994). The use of purely behavioural methods has become increasingly rare in special schools and school and college sessions observed for this research were certainly not behaviourist in the strictest sense.

However, approaches used were very directive; the teachers spoke of this as necessary to get students to do anything and also spoke of the need for their students to learn to sit quietly or wait patiently. They were, nevertheless, pleased by the involvement and independence of their students that they witnessed at the ISC

and attributed this to the fact that ‘staff took a back seat’ there (see teacher interviews). Some school/college staff found it hard to stand back at the ISC at first, wanting to make the most of the learning opportunity, or for their students to show themselves in the best possible light. Ware (2003) noted a tendency of carers of infants with disabilities to be more directive in their interactions, wanting the children to do more, rather than waiting for their spontaneous responses.

Advocates of interactive methods (e.g. Coupe O’Kane *et al* 1994, Garner *et al* 1995, Collis and Lacey 1996) have stressed the importance of real choice and control, however, interviews with teachers for this research suggested that approaches used in the students’ usual learning environments included only limited choice: Teacher 3 spoke of free play as taking place on Friday afternoons only, Teacher 2 of choosing as being incorporated into the curriculum when the students reached fourteen.

Research in ISCs and other informal learning environments has highlighted the importance of choice and control in relation to intrinsic motivation (Falk and Dierking 2000, Paris 1997, Csikszentmihalyi and Hermanson 1995). At the ISC which is the setting for the present research the invitation to the students to choose their activities was made explicit. For this choice to be genuine it was important for the environment to be safe (many of the restrictions placed on the middle group of students in the science laboratory at school are justified for reasons of safety). Having control over time also seemed to be an important element for the students in this study, control over the time they spent in any particular activity, spending a long time in repetitive actions before moving on to making adaptations, or

alternatively moving quickly on when they had achieved a goal, or simply found something without interest, before they got bored.

Control in relation to interactions with other people

The importance of interactions with other people in the learning process, the socio-cultural dimension, influenced particularly by the work of Vygotsky (1978) and others (e.g Vygotsky and Luria 1994, Bruner 1996, Rogoff 2003) has been increasingly recognised in both formal and informal learning environments. In the ISC choice and control within these interactions emerged as an important factor in promoting the students' engagement with the activities. They are also central to interactive approaches; 'Intensive Interaction' (Nind and Hewett 1994), for example, depends on the kind of contingent responding which is part of interactions between normally developing infants and their caregivers. For the students in the present study independent, engaged behaviour seemed to depend on remaining in control: contingent scaffolding (Wood *et al* 1976), receiving just the degree of support requested or clearly needed to help them move on, enhanced engagement, direction or instruction, particularly where a large amount of language was involved, reduced it.

The very striking contrast in students' behaviour from one situation to another appeared to relate to a large extent to whether or not they were given choice and control; some students changed even within the active part of an ISC session from reluctance to do anything when being directed to eagerness to carry out activities independently once left to do so.

The nature of the environment

The nature of the environment and the activities at the ISC links to much of the above. Although little of the students' behaviour was actually coded as play (possible reasons for this have been discussed above), the activities met many of Bruner et al's (1976) criteria for play: the dominance of means over ends; a lessening of physical risk and risk of failure; a temporary moratorium on frustration due to the precedence of process over product; free attention: the freedom to notice seemingly irrelevant detail; and the fact that it is a voluntary activity, self-initiated. These criteria are not exclusive to play and most are important features of interactive approaches, in particular the dominance of means over ends, precedence of process over product (Smith et al 1983, Collis and Lacey 1996, Nind 2000). Nind and Hewett (1994) saw the task-free nature of the activities as an essential component of Intensive Interaction; in fact in the ISC the students in the study tended to work to a goal but a goal that was almost always self-imposed. The voluntary nature of the activity appears to have been a powerful factor in the clear, intrinsic motivation of the students. The students' pleasure was very clear indeed at the ISC, especially when they achieved a self-imposed goal but also pleasure at the feel of the wind from the Wind Tunnel or at a game involving the strong pull of the Electromagnet. Griffin (2004, p.63) suggested that when students spoke of an ISC visit as being 'fun', this was a '*complex notion which includes feelings of mastery and control*'.

Where process takes precedence over product and there is no externally imposed goal the risk of failure is much reduced. In the ISC the students were almost never upset or frustrated if a goal they had set themselves was not achieved: Bruner et al's

(1976) 'moratorium on frustration.' Lacey (1991) points out the need for learners to be able to make mistakes in a secure environment. The dual security – physical and emotional – appears to have given the students space to explore, and such an environment could perhaps even provide, on a small, concrete, scale, what Hodgkin (1985) has called 'potential space' or 'room to be and to become'.

The environment provided the opportunity to explore or simply try things out. Bruner et al's (1976) definition of play – and that used for this study – includes 'combinatorial play' the playing about that promotes physical competence but which also allows the freedom to notice seemingly irrelevant detail when there is no pressure to do things in a certain way or in a certain time. It has been suggested that this opportunity to play about (McConkey 1981), to investigate the properties of a spoon other than for getting food into the mouth (Smith 1982), is an element that is missing from traditional behavioural approaches that may account for the fact that they tend not to produce flexible learning. Moyles (2005) having listed the vital contributions that play can make to learning deplores the fact that even in early years settings it is seen as secondary to 'work' and is increasingly squeezed out as children get older by curriculum initiatives and targets.

The design of activities

Recent research in ISCs (Allen 2004) has shown the importance of 'apprehensibility' of activities but what is apprehensible to one person may be incomprehensible to another and just boring to a third; motivation depends on a fine balance between something being too complex and not complex enough (Berlyne's (1960) creativity curve). Some activities at the ISC seemed to lend themselves to

exploration (the Wind Tunnel, Motion Detector or Electromagnet), others to adjustments to achieve a goal (Pulleys, Tilting Gutter), however this depended greatly on the individual student; where Karen explored at the Motion Detector, Alan and Richard appeared not to understand the need to move in front of the ultrasonic beam in order to create the graph on the computer screen.

The multi-sensory nature of the activities: by-passing language

The first section of the literature review has detailed the long tradition of belief in action as the basis for understanding the world, with enactive learning (Varela *et al* 1993) and the senses at the heart of this understanding. Yet, despite a recent increase in interest in multiple 'intelligences' (Gardner 1983) and diverse learning styles (e.g. Riding and Rayner 1998), in both mainstream and special education, a hierarchy remains, valuing the linguistic and the abstract over other modes of input and expression (Gardner 1983, Hodgkin 1985). Advice for students with language difficulties tends to centre round ways of making language more accessible (e.g. Tilstone *et al* 1998) rather than exploring ways of by-passing it. The contrast in the responses of students in the present research according to whether sessions were language-based or multi-sensory and active has been described above, as has the extent to which they were able to show understanding and recall, as well as some transfer of what was recalled to a new situation even when they were unable to put these things into words.

5.2 Alternative Explanations

I have suggested that differences observed in students' responses, in particular the high degree of independent and engaged activity shown in the active sections of

ISC visits, were due to particularities of the learning environment, that is to pedagogical factors, notably the amount of choice and control given to students and the multi-sensory, active and playful nature of the activities. It is important, however, to consider alternative explanations for these differences:

The novelty of the ISC visits may have been a factor; it is true that the follow-up sessions which took place in the students' usual settings were at least as successful as ISC sessions but even in these the activities themselves retained a certain novelty and the sessions were not taken by the students' usual teachers.

Particular circumstances in the school or college sessions observed may have led to their being more language-based or more controlled than usual: the fact that saleable products were being made or the need for safety in the science lab. However, the teachers confirmed sessions observed as not being out of the ordinary and the aim anyway was not to seek representative sessions but to observe the students' responses in these particular sessions and the effect of approaches used in these.

Students could have been having an 'off day' when observed to be less motivated and independent: Michael certainly seemed less responsive on his second visit to the ISC; Alan had recently had vaccinations before the session in the greenhouse, he nevertheless showed very similar behaviour in all language-based sessions and when being directed by staff or fellow-students, whether in college or at the ISC.

5.3 Issues Relating to the Research Design and to Methodology

5.3.1 Risks to validity

Only one, then two, video cameras were used to focus on at least three students per session and of necessity there are gaps in the record for any individual for any given session. This position was a trade-off between having a large enough number of cameras to provide a complete record and these cameras being unobtrusive, as well as the practical considerations of availability of cameras and people to film. The resulting picture may be incomplete but it is clear from the videos that they show much that was missed by observers and even without filming every moment of a session for every student what is powerful is the contrast for an individual from one situation to another within a session, from language-based to active, from directed to independent activity.

Perhaps the greatest risk in a study of this kind is that of misinterpretation of observed behaviour, especially as it was not possible to ask participants for their own interpretations. The checks that were used to insure against this have been described: in particular the students' teachers were asked to view, and comment on, a number of the videos, as were fellow-researchers ('critical friends'). Inter-rater agreement was used to check both interpretation and coding. Care was taken not to attribute development in the students' responses to the ISC from one year to the next to their previous experience there as other factors, including general maturity, are likely to have been much more significant over this period of time.

It was not always easy to decide between the codes allocated to different types of engaged behaviour in analysing the videos, particularly if an activity had not been filmed in its entirety, hence the importance of rigorous inter-rater agreement checks. For instance, combinatorial play (trying out the possibilities of the equipment) could be difficult to distinguish from working to a goal, as sometimes the goal only became clear from the student's response when it was achieved (or not). Equally play could resemble exploration/experimentation; the latter was distinguished by evident interest in cause and effect and systematic variation to find out more. Behaviours were coded to the lower code if there was doubt or, if they were really felt to be somewhere between the two, or it was impossible to distinguish between two codes, both codes were given (for example 'a/b' when students could have been listening but showed no outward sign of doing so) but these sequences were colour-coded to the lower code on the colour charts.

5.3.2 Generalisation

The aim of the research was not statistical generalisation and numbers of participants and research design would not have permitted this. However the methodology chapter has explored a number of ways in which generalisation may be possible in interpretive research that are applicable to this study.

Schofield (1993, p.98) suggested that it is possible to generalise 'to what may be' or 'to what could be', selecting a situation that is in some way exceptional so that it sheds light on what could be, given the right circumstances. The aim of the present research was to explore a situation that had not previously been studied and that could therefore shed light on what 'could be' in these circumstances. The results

suggest that this was an environment that could be highly successful for these particular students in ways that may have wider applications.

Stake (1995) described as ‘*petites généralisations*’ general statements made within a study, for example that a certain participant repeatedly responds in a certain way to a particular situation. This was important in the present study where one of the most striking aspects of the findings was the extent to which students’ responses were different in different situations but in a way that was consistent within these situations.

Yin (1994) maintained that case studies (like experiments), rely on ‘*analytical generalization*’, that is generalisation to theory. In other words they can be compared against an existing theory or theories in terms of whether or not they provide further support for a particular theory and/or do not support a rival theory. Support for a number of bodies of literature has been discussed, notably those relating to the efficacy of interactive approaches and to the importance of a range of interacting pedagogical factors in promoting engaged and independent learning, in particular multi-sensory approaches and choice and control in interactions with other people as well as in the learning situation.

Lincoln and Guba (1985) suggested that naturalistic enquiry encourages generalisation because ‘*it makes contact with the readers’ own tacit knowledge of related or similar situations.*’ It is hoped that the present research will make contact with readers’ experience and one of the aims was the kind of rich

description that makes this possible; implications for practice are discussed in below.

Stake (1995) and Punch (2005) have argued that interpretive research and in particular research using grounded theory strategy may be used to generate propositions and to extend or develop theory, in this case the findings can be seen as *potentially* applicable to other cases (Punch 2005). Hypotheses generated by and grounded in the data have been discussed and the extent to which it was possible to explore these within the scope of this research; implications for future research are also explored below.

5.4 Implications for Practice

This research constituted an initial exploration of a pedagogical situation that had not previously been studied for students with SLD and involved only a small number of students. Nevertheless, I would argue that it has important implications for practice and that it suggests avenues for exploration for future research. Ways in which generalisations can be made from interpretive research and their application to the present study have been discussed above; an important factor is the degree to which they make contact with readers' experience and I have sought to give sufficient detail to enable connections to be made with the experience of the many practitioners who are constantly looking for ways of extending the range of approaches that they use with their students.

The most striking finding to come out of the study was how different individual students could be in different situations; students who had shown a reluctance to take any independent initiative, or indeed, for some, to take part at all, in language-

based, closely directed sessions, were very different when given the opportunity to carry out multi-sensory activities in their own way and in their own time. In one situation a number of students had conformed to the picture painted of them by their teachers - unwilling to do anything unless specifically told, needing very directive methods in order to achieve anything - in another they appeared quite the reverse. Some authors have suggested a need for increased direction as part of a profile of learning difficulties (Mastropieri *et al* 1997, Read 1998, Wishart 2005). For the students in this study, at least, the reverse appeared to be true: in the ISC environment most were eager to do things independently, all were willing and able to do so, emphasising the need to beware of self-fulfilling prophecies.

A number of elements in this environment appeared to promote independent and engaged behaviour for these students:

- Real choice: an environment where this was possible and safe.
- Control over time and over what to do, and indeed whether to do anything, although it was very rare that students opted to do nothing.
- Having a choice about whether or not to work with someone else: this was only possible for small groups, and even then there was some need for negotiation and mediation, as one person's choice might not coincide with another's (Alan wanted to do things on his own, Gemma wanted to keep him with her, following her directions).
- Genuine contingent scaffolding: help being readily available when requested and offered when clearly needed but not imposed. An appreciative audience was also frequently welcomed.

- **Lack of pressure:** the fact that there were no externally imposed tasks meant there could be no failure and frustration was diminished. There were no time pressures for students or staff (apart from the need to return to school or college at a certain time), no pressure to achieve targets, National Curriculum or otherwise.
- **Appealing activities** – large, bright and playful - but also apprehensible.
- **The activities required no linguistic ability;** it was possible for students to explore them and to show their understanding and demonstrate their discoveries without language.

Implications for inclusion

The fact that activities were open-ended, task and target-free meant that they could be used with a wide age- and ability-range; they worked at very different levels even within the groups in the study, they had also worked for mainstream groups from Early Years to Year 6. They have not been trialled with mainstream teenagers but certainly interested adults, (the ‘Thump Wave’ intrigued two eminent scientists sufficiently for one of them to return with a CO2 cylinder in order to render the current of air coming from the drum visible and prove that it was indeed a vortex!)

Group work has often been suggested as a way forward for mixed ability classes (e.g. Gardner 2002). For the students in this study it tended to result in the more articulate or forceful students dominating and directing peers. Truly collaborative group work is a sophisticated skill and needs careful preparation; where it worked for these students it did indeed appear to enhance their experience but in this case it was always self-chosen and usually in a pair rather than a larger group.

If non-verbal learning is to be truly valued, it is not enough to use visual or practical means to provide access to what is essentially a language-based curriculum. This study suggests that for these students enactive learning (Varela *et al* 1993) was taking place; it is not suggested that this approach should replace others but that it could be used alongside, on an equal footing. The extent to which students could show understanding that they could not put into words also has implications for assessment.

It appears to have been the degree of choice and control offered to the students in the present study, that made it possible for them to use the activities in their own way and therefore at a range of levels: choice about what to do, how to do it and how long to do it for, as well as release from the pressures of tasks and targets. It seems possible that these would also be important factors in an inclusive learning situation.

Again, it is not suggested that this approach should be used on its own, that it should replace other methods, but that it may be a useful option on the 'continua of approaches' available to teachers (Norwich and Lewis 2001).

5.5 Implications for Future Research

An exploratory study of this nature inevitably raises as many questions as it answers and any answers can in any case only be tentative and relate mainly to this small number of individuals in this context. Nevertheless it suggests avenues and hypotheses for future research.

The previous section has summarised the approaches that appeared to be effective for a small group of students in a particular situation, approaches that could be explored for other groups from special and inclusive settings. The question also arises of how such 'enactive' learning could be used to develop understandings derived from it. If we accept action as a basis for understanding and learning as a 'continual process of remembering and connecting' (Rennie and Johnston 2004) the important question is how students can be helped to make such connections. Students in the study were able to show that they remembered what they had done at the ISC and to some extent that they could use this in a slightly different situation, nevertheless this was not the main focus of the research and much more would be required to answer questions about the extent of students recall and transfer or generalisation of what was recalled. These questions are likely to be fundamental in considering the contribution experiences such as the visit to the ISC could make to the students' knowledge and understanding even if this is only a tiny thread (Allen 2004).

It has been suggested that non-verbal, enactive, learning should be valued for its own sake, nevertheless language is likely to be an important element in helping students move from an implicit to an explicit understanding (e.g Karmiloff-Smith 1996) of their experiences somewhere like the ISC and of the concepts involved.

This research was based around a science centre, and it may be that scientific concepts, especially those concerned with observable phenomena of the everyday world, lend themselves to this type of approach. It would be useful to look at whether this type of learning environment could be created for other subjects;

informal learning environments – museums or visitor centres – dedicated to history or geography, for example, exist and it would be interesting to explore how they could be adapted for use on a smaller scale and whether such centres, or indeed science centres, could be created within schools or by groups of schools, to the same effect.

CHAPTER 6: CONCLUSION

The aim of the research was to explore a situation that had not previously been studied and the possibilities of a particular pedagogical environment for a particular group: visits to a small interactive science centre by a group of students with SLD. Using grounded theory techniques the study has not only shown very high levels of actively engaged and independent behaviour in this setting but the extent to which these students' behaviour was different in different situations. The use of small-scale, detailed, quantitative and sequential analyses has made it possible to explore hypotheses grounded in the data and the findings strongly indicate that these differences in behaviour were related to pedagogical factors within the learning situation.

The study provides strong support for a number of theories, in particular those relating to an interactive view of learning and the efficacy of a pedagogy that is student-led and process-based, rather than target-led and product-based (Smith *et al* 1983, Nind and Hewett 1994, Collis and Lacey 1996, Nind 2000). Findings also support a number of other recognised features of interactive approaches, foremost among these being the importance of students having genuine choice within the learning situation and control over activities and within interactions with other people (Smith 1994, Garner *et al* 1995, Ware 2003). Choice and control emerged as vital in fostering independence and intrinsic motivation for the participants in the study.

The task-free nature of the activities, a further feature of many interactive, process-based approaches (e.g Nind and Hewett 1994, Collis and Lacey 1996), the lack of externally imposed targets or goals and the opportunity to 'play about' (Bruner *et al* 1976, McConkey 1981, Smith *et al* 1983), all appear to have contributed to creating a situation in which the students felt free to do things in their own way, to explore and to make mistakes without frustration (Bruner *et al* 1976, Lacey 1991). The setting was risk-free in this emotional sense but also in a physical sense making it possible to allow the students real freedom of choice within it, creating space and freedom for exploration, moving towards Hodgkin's (1985) idea of potential space or 'room to be and to become'. Having the choice over how long to spend at any given activity, having time to develop an activity or being free to move on from one that did not motivate, also emerged as important. In situations where the students in the study were given this freedom they appeared highly motivated; almost all were actively engaged for the vast majority of ISC and follow-up activity sessions. The exceptions were Jackie and Michael on their second visits to the ISC: Jackie spent most of her second visit watching other students, but with great interest, Michael, during his second visit, frequently returned to 'twiddling' pieces of string or tape measures, resting his head on a convenient table, his thumb in his mouth. Nevertheless, both had shown how involved they could be given the right circumstances and the right activity (the Circuits for Jackie, the Wind Tunnel for Michael on earlier visits). The nature of the activities also appeared to be of importance in other ways: they were novel for the students but also 'apprehensible' (Allen 2004) at a range of levels. Some were more successful than others and this varied from one individual to

another; the need for balance between too little stimulation and too much to produce creativity (Berlyne 1960) was apparent, between something that was intriguing and something that was incomprehensible.

The success of the ISC environment for these students appeared to transfer well to school or college when a similarly student-led and process-based environment was created in the follow-up sessions, one in which the students were explicitly given choice and control. The exact role played by the fact that the activities and the person bringing them into school retained some novelty was difficult to assess but it seems unlikely that this could entirely account for the fact that engagement levels were frequently even higher in this situation.

The role of other people, social constructivism and socio-cultural aspects of learning (Vygotsky 1978, Vygotsky and Luria 1994, Bruner 1996, Rogoff 2003) emerged increasingly as vital during the research. However, interactions with other people were found to have both negative and positive effects and control was also found to be an essential element in this distinction.

Contingent scaffolding (Wood 1976, 1998), especially when non-verbal or when language was minimised, had a positive effect on student engagement and was often requested by them. Attempts to direct or to use the situation as an opportunity for instruction, especially when this involved a high language content (Boekaerts 1994), tended to reduce student motivation. Some of the participants were passive when being directed to the point of doing nothing at all unless specifically told to but active and assured when given control over what they were doing. In the former situation they appeared to conform to a view of students with learning difficulties as needing more direct instruction

(Mastropieri *et al* 1997, Read 1998, Wishart 2005), in the latter their responses were quite different, emphasising the need to beware of self-fulfilling prophecies (Hart *et al* 2004).

A further feature of the learning environment that emerged as important was the multi-sensory nature of the activities: the students were much more responsive in situations where language was not essential. Given their language levels this may seem unsurprising but it is easily forgotten in a culture and an education system which places so strong an emphasis on language (Gardner 1983, Hodgkin 1985). Findings support a view of the importance of taking into consideration a range of cognitive and learning styles (Riding and Rayner 1998) and of recognising a range of 'intelligences' (Gardner 1983), especially in this case where one mode of input (language) was so difficult for the students. However, this is not to suggest that this necessarily needs to be on an individualised basis (Ainscow 1997); recent studies have shown that it is possible to develop pedagogies that are accessible to a wide range of learners (e.g. Corbett and Norwich 1999, 2005; Hart *et al* 2004). Our previous research in the ISC (Brooke 1994, Brooke and Solomon 1998) as well as the present study have shown the activities in the ISC to have this potential, to be accessible at very different levels and to provide opportunities for open-ended exploration. The learning environment of the ISC appeared to emphasise and bring out the strengths, rather than the weaknesses, of this small group of students with SLD.

The possibility of by-passing language emerged as important for another reason: the students were also able to show a degree of understanding which

they could not express verbally, even with the support of sign, mime and demonstration. The study has explored the use of video filming as a means of demonstrating this; filming of follow-up sessions was also able to show how much the students recalled of their visits and that most were able to use what was recalled in a slightly different situation in a way that was not at all evident in language-based situations.

This study constituted an in-depth exploration of the possibilities of a particular learning situation for a small group of students. It was possible to formulate and explore hypotheses about why it was apparently so successful for this group, and implications for practice have been discussed, but clearly this was only a beginning, sign-posting directions for future research.

Prominent among the questions raised by the research is that of whether this type of pedagogical environment would prove equally successful for other individuals and other groups. Also of importance is the question of how an experience such as the visit to the ISC could fit in with students' overall learning. The long history of belief in action and experience as bases for understanding has been traced in the literature review, and the study suggests that this type of environment could provide solid foundations for this understanding, but the question remains of how to build on this and how to help these students move on from implicit to explicit understanding (Karmiloff-Smith 1996); it may be that different approaches would be needed for this. Nevertheless, the design of the current study enabled a rich and detailed picture to be elicited and the emergence of grounded theory as well as

empirical evidence to support existing theory, thus making a worthwhile contribution to knowledge.

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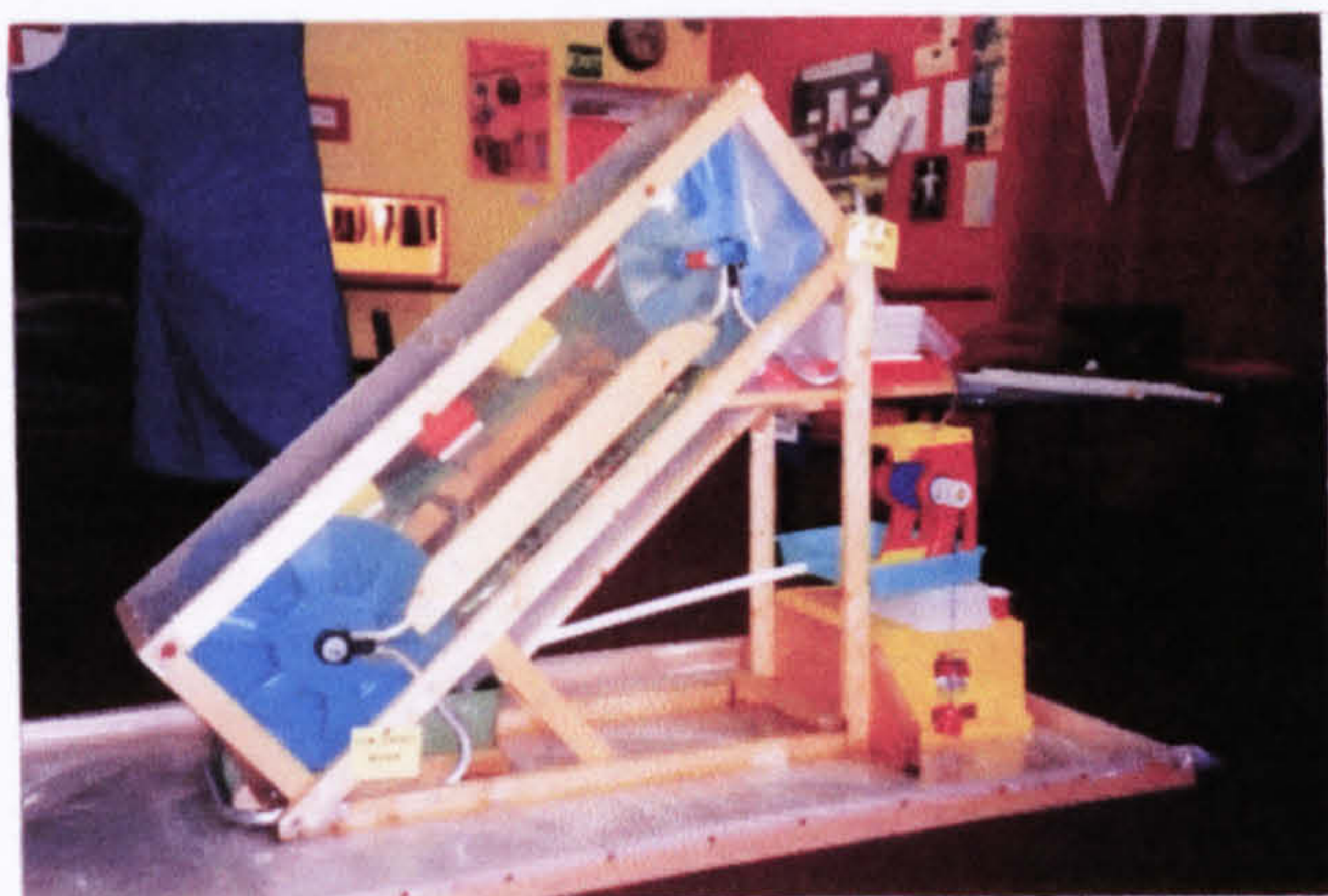
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APPENDIX I: ACTIVITIES AT THE SCIENCE CENTRE

ENERGY AND ELECTRICITY

Water-Lift:

When the handle is turned a series of beakers carry water from the lower reservoir to the upper reservoir, from there the water travels down a tube and can be used to turn a water wheel and lift a small bucket.



Breathing Skeleton:

A life-size model of a human skeleton with a balloon 'diaphragm'. When the diaphragm is pushed or pulled the skeleton blows air into, or sucks it out of, a plastic bag. Students are also invited to find out how much air they can blow into a bag in one go.



Circuits:

Different types of circuit (ring circuits at one table, series circuits at another) are provided for students to complete to make lights go on or spinners spin.

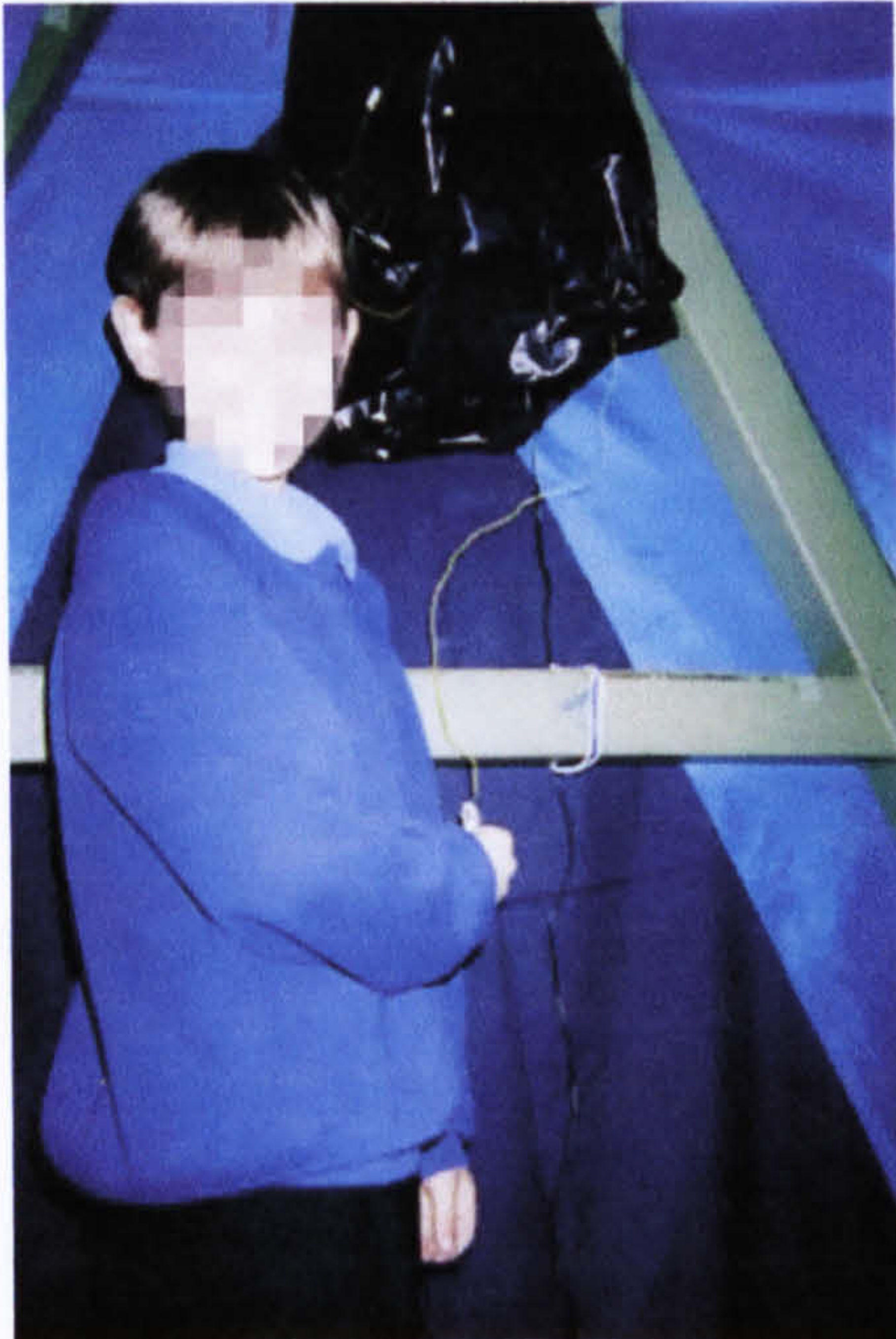
**Transistorised Light Box:**

Wired up so a very small current will light the bulb when the circuit is completed. Students can try any number of materials between the wires to complete the circuit, including water or themselves! Enough current will pass through a circle of people holding hands to light the bulb.



Human circuit:

A circuit arranged so that when the students stand on a foil covered pad (without their shoes) and hold a wire, they complete a circuit and a tiny light lights up. This is inside a tent to make the light more visible.

**Marble Run:**

A commercial set of plastic tubing which can be fitted together to make a run for marbles.



Heated House:

Model house with removable insulation. Temperature sensors linked to a computer display.

**Wind Generator:**

Using a stream of air to turn the sails and generate electricity.



Pendulums:

Balls on strings to swing with graduated lines behind to show how far they swing.

**Follow-up activities relating to Energy and Electricity:**

- The water wheel from the Water-Lift.
- The marble run.
- The electricity box with a different selection of objects to test.
- Wires, battery and bulb to make a simple circuit.

FORCES AND MOVEMENT

The Water-Lift was retained with these activities.

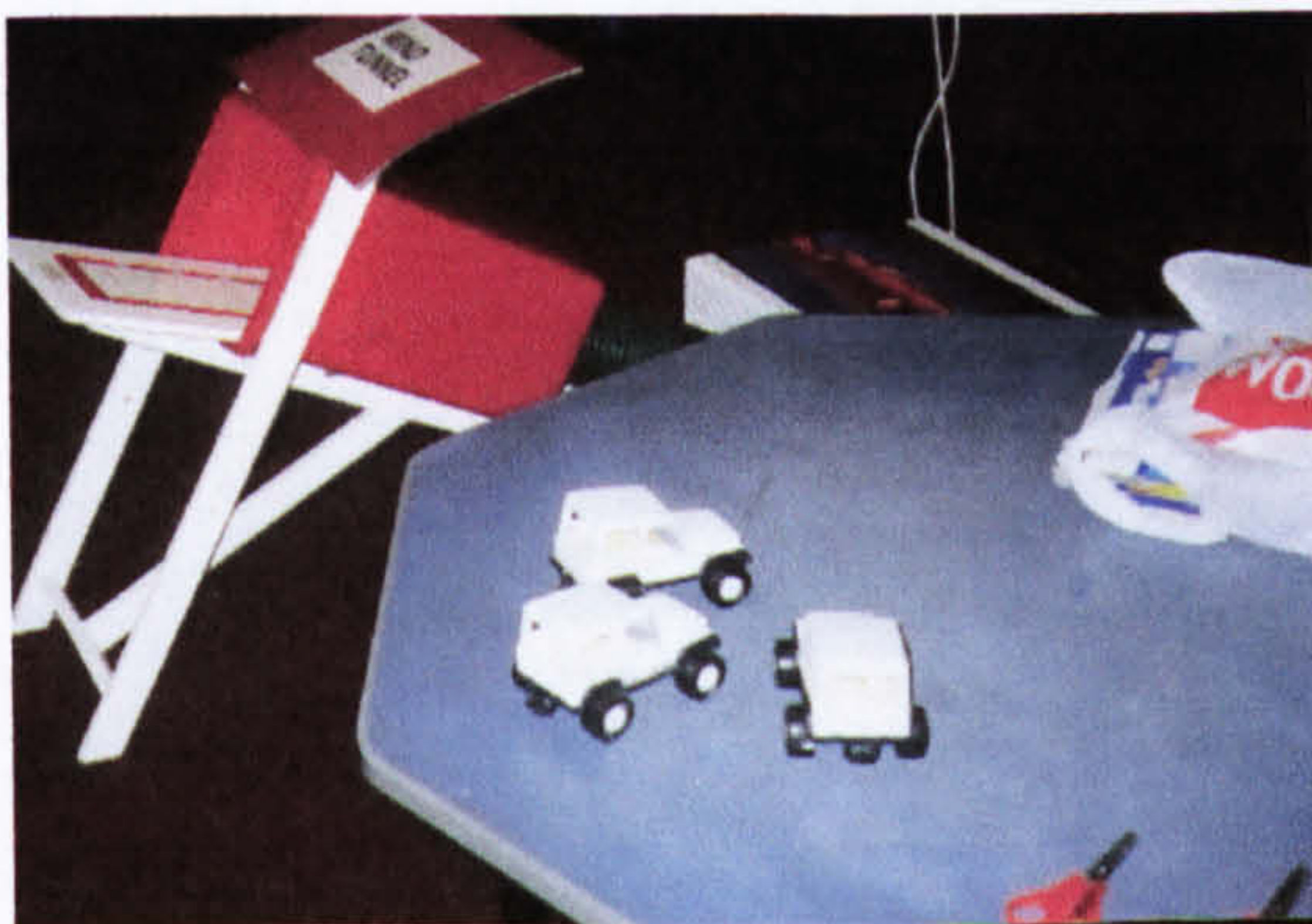
Skeleton Riding a Bicycle:

By turning the pedals, students can help the skeleton ride the bicycle and watch the effect on his balloon muscles. There is also a disembodied 'Leg' to which they can add their own muscles and make it kick.



The Wind Tunnel:

A reversed vacuum cleaner with a test pad. Students are given a variety of toy cars to test and card to change the shape of the chassis (or simply to try out in the wind).



The Tilting Gutter:

A piece of guttering that can be tilted at different angles in order to get a ball in a bucket.

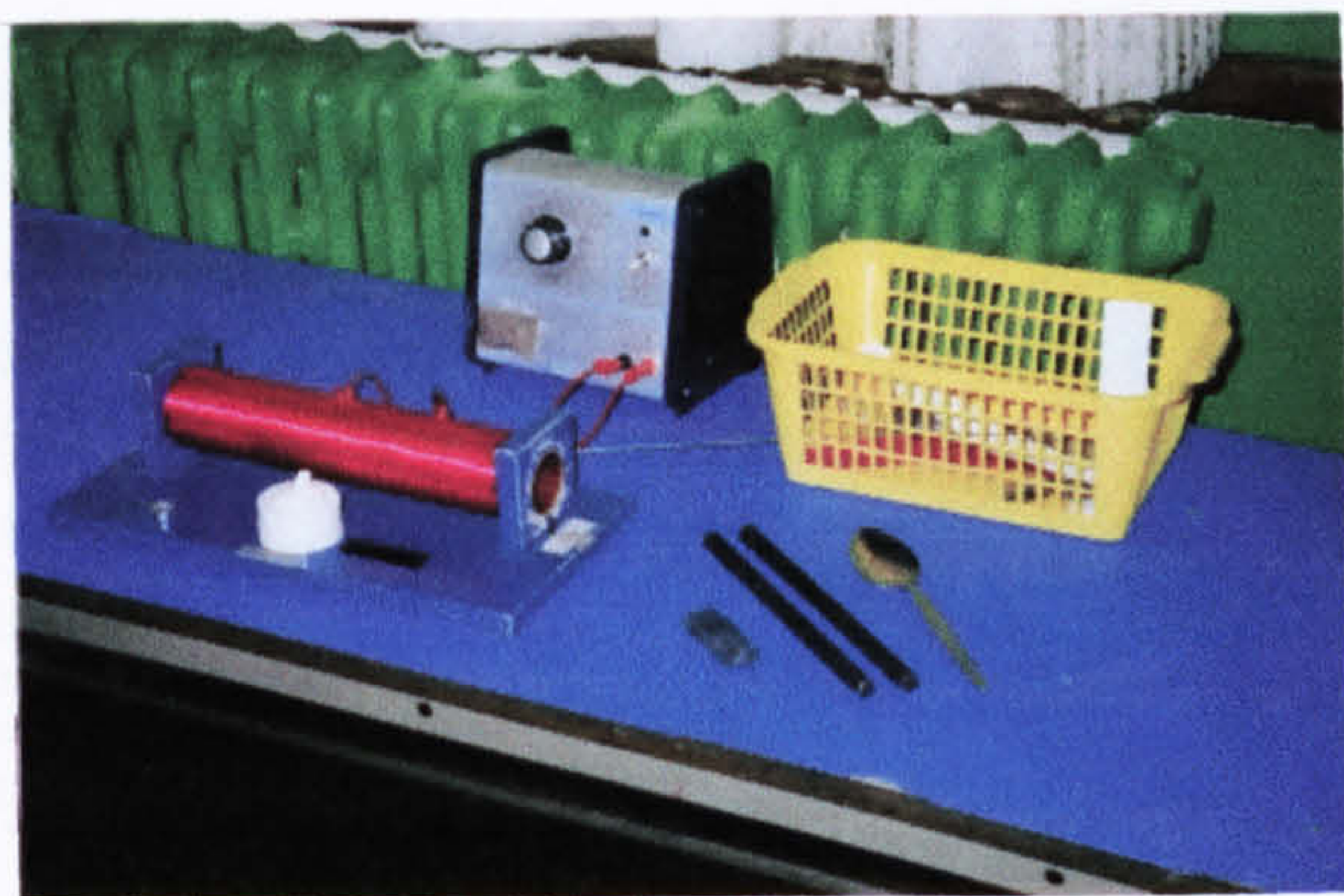
**Pulleys:**

A pulley system on a large metal frame. One rope (red) lifts the bucket, the other (green) tips a ball from it into a gutter so it rolls down into another bucket on a spring.

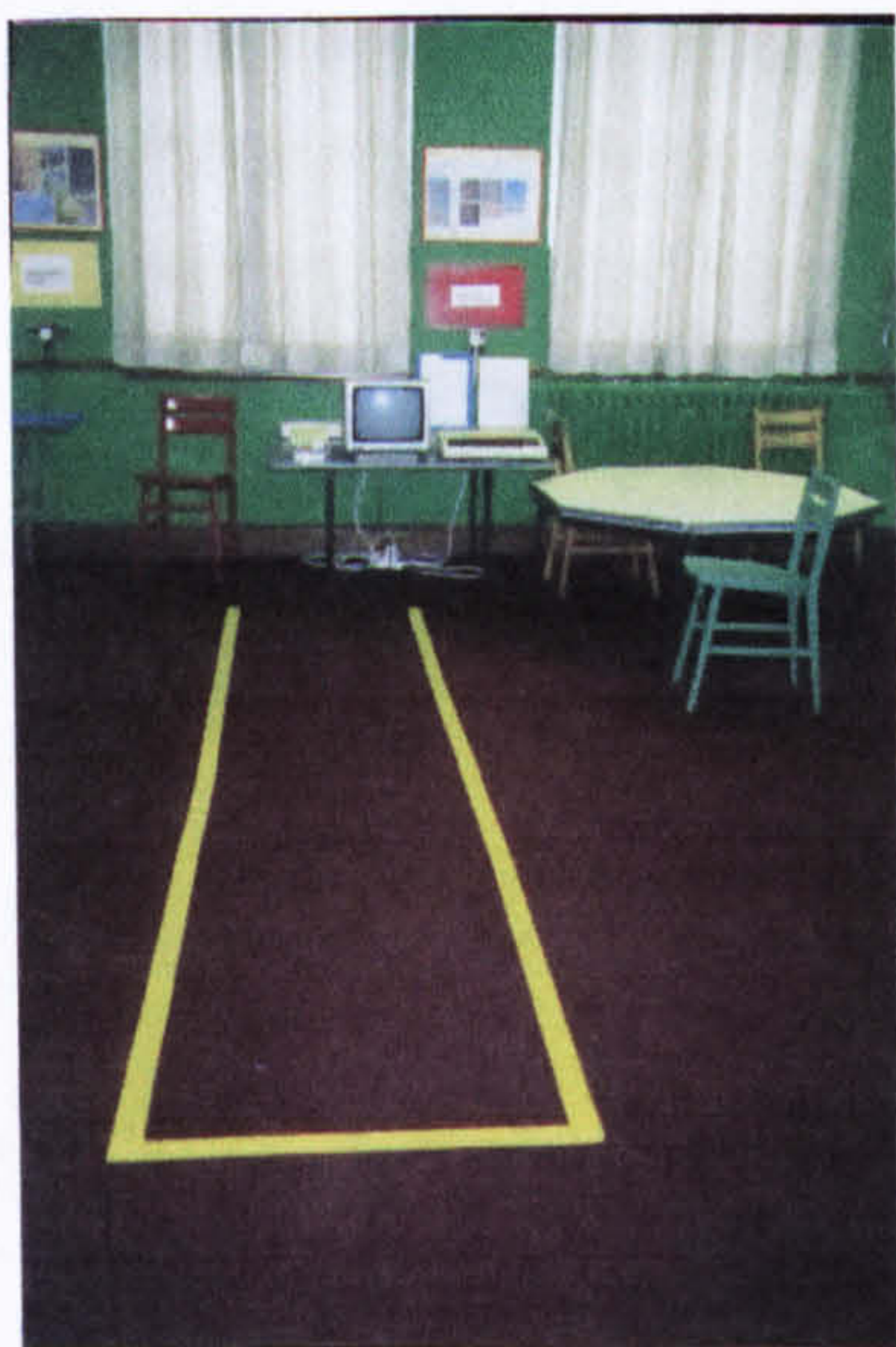


The Electromagnet (solenoid):

A large electromagnetic coil with a variety of objects made of different materials to try out in it. Students can also turn it on and off.

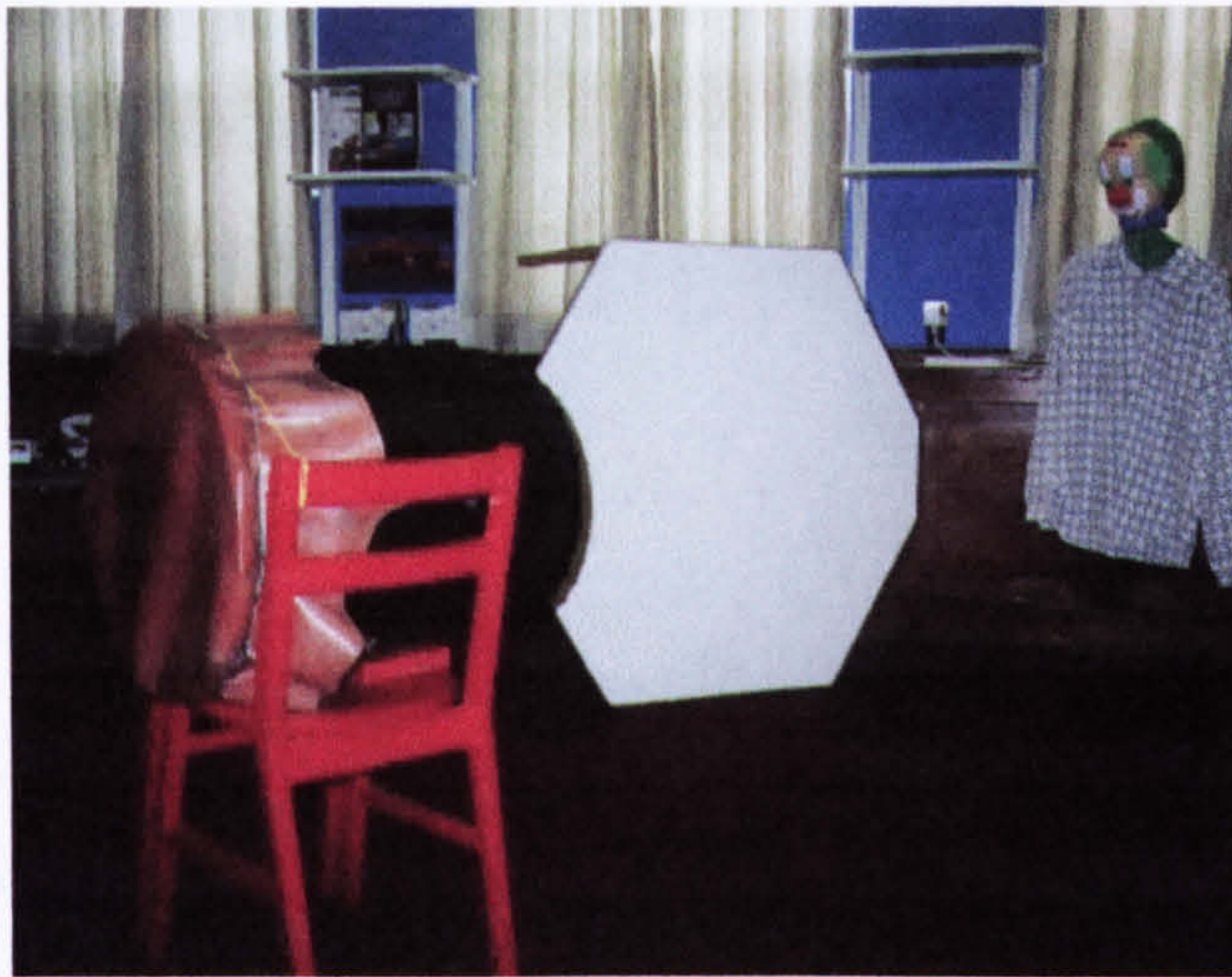
**Motion Detector:**

An ultrasonic beam detects motion within a certain area (the yellow box marked on the floor). The echoes are picked up by the computer and a time/distance graph is drawn on the screen. This lasts only few seconds and then the apparatus needs to be re-set by pressing keys on the computer keyboard in a given sequence.



'Thump-wave' and Clown:

A dustbin with a hole in the bottom and a rubber sheet stretched across which, when hit, causes a current of air to travel across the room and ruffle the clown's shirt (or the hair of anyone standing in the way)



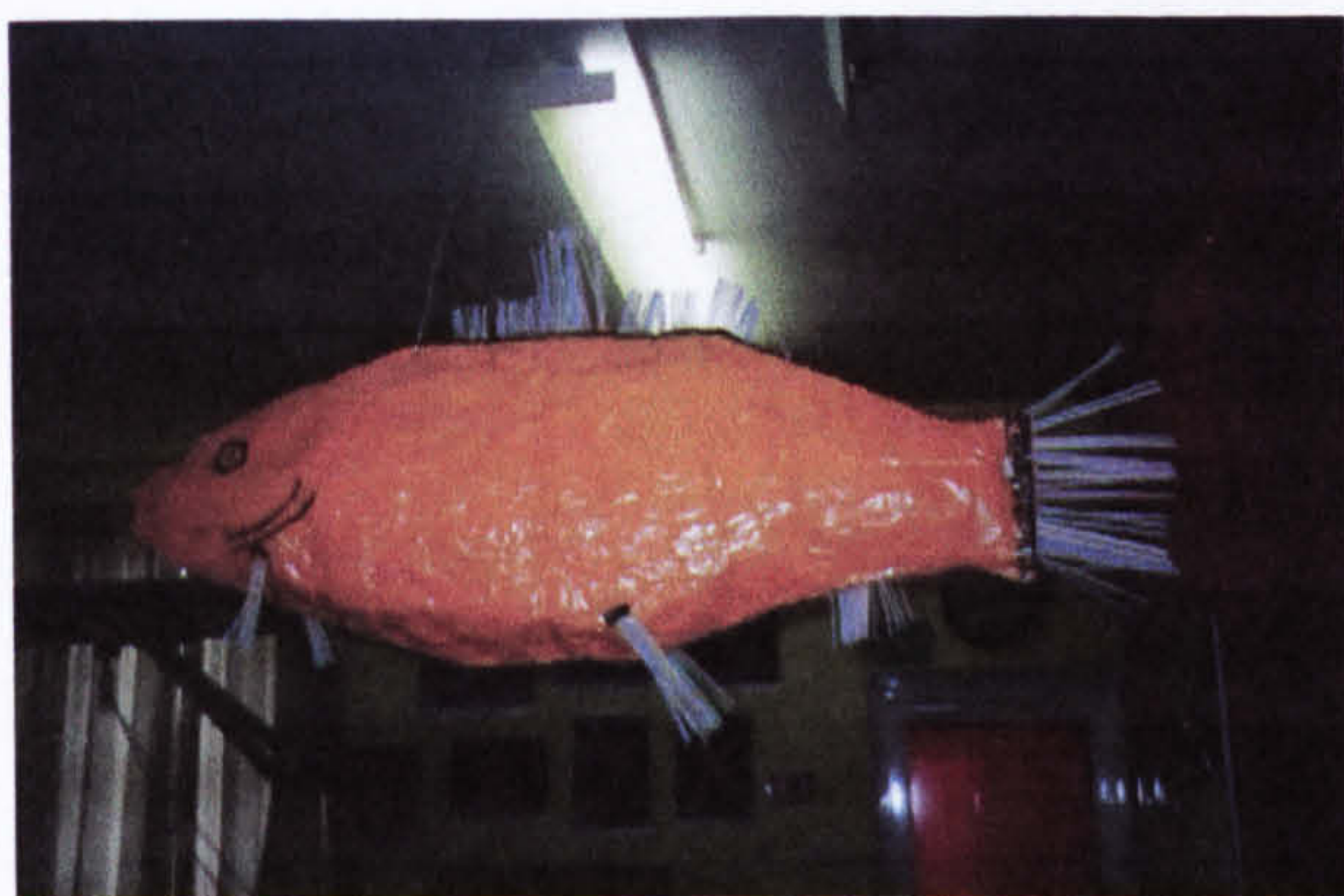
Giant Dominoes:

One set is fixed to a board which can be raised or lowered, the others are loose.



Giant Goldfish:

A tank of live goldfish with magnifying lenses for students to watch how they move. Straws to make fins and water to test them in. A model of giant fish.

**Follow-up activities taken into school:**

- The solenoid plus a variety of smaller magnets and materials for making circuits
- A chairback version of the Tilting Gutter
- Broom handle, wooden pulleys and ropes for DIY pulleys
- The dominoes with a ping pong ball to place on the end one and a pot to catch it in for an additional challenge
- A hair dryer to make the cars move instead of the Wind Tunnel

APPENDIX II: CODING SYSTEMS

Open Coding

1. Independent/passive

1+ student chooses activity/working on own initiative

1- student follows directions

2. Types/levels of engagement

2a distracted (attention not on activity)

2b unfocused (repetitive, no goal)

2c inactive – passive – watching/listening, no obvious response

2d following instructions

2e focused on activity, initial interest, no goal

2f playing around, enjoyment of physical activity/sensation, trying out new activities with equipment, no particular goal

2g make-believe (e.g. using piece of equipment to represent something else.

2h working towards a goal set by someone else

2i working towards own goal

2j problem-solving (problem perceived, adapting activity to solve it)

2k experimentation to achieve goal (trying out new ways to achieve unchanged goal)

2l interest in cause and effect, curiosity (what is happening and why?)

2m exploration (to find out more, what happens if ..?)

2n uncodable

2o off camera

3. Interactions with others

3a (+ or -) Co-operation, working alongside, sharing equipment, turn-taking

3b Collaboration (working together towards common goal)

3c Communication

- asking for/demanding help (student-staff, student-student)
- look what's happening (student-staff, student-student)
- look what I've achieved (student-staff, student-student)
- inviting collaboration (student-staff, student-student)
- instructing others (staff-student, student-student)
- leave me alone (student-staff, student-student)
- this is mine (student-staff, student-student)

4. Responses to staff intervention

4a staff directing, student complies (+ or -)

4b staff instructing, student listens/responds (+ or -)

4c staff questioning, student answers (+ or -)

4d staff scaffolding (verbal/non-verbal), student responds (+ or -)

Theoretical Coding: levels and types of engagement with activities with operational definitions

- a) Attention not focused on activity.**
Student’s attention focused elsewhere than on activity. Repetitive action, no apparent interest in the activity itself e.g. turning a handle without looking at the equipment.
- b) Focused on activity, initial interest, no apparent goal.**
Watching others, not touching equipment but clearly interested. Not participating, looking on.
- c) Trying out /playing.**
Touching, trying out equipment, playing around with it, enjoying physical sensations, but no other apparent interest in what is happening, no apparent goal. Make believe play (e.g. using a piece of equipment to represent something else).
- d) Following instructions.**
Following someone else’s instructions step by step.
- e) Working independently, or in collaboration, towards goal.**
This included participating in someone else’s goal. Not making any significant adaptations to achieve the goal.
- f) Making adaptations or adjustments to achieve a goal.**
Altering activity in some way (not simply repeating previous action), trying out new combinations to achieve a goal. Problem-solving.
- g) Investigation/Exploration**
Clear systematic variations in activity designed to find out more: to find out what is happening and why, interest in cause and effect (investigation) or to find out more ‘what happens if I do this then this ...?’ (exploration)
- n) Uncodable**
For example back to camera or half hidden (if the student was clearly involved in this situation and therefore sequence could be coded at least ‘b’ this was noted as x/b)
- o) Off-camera**

Key for colour coding:

a	b	c	d	e	f	g
Not focused on activity	Initial interest	Trying out/ playing	Following instructions	Working to goal	Making adaptations	Investigation/ exploration to find out more

n	o
uncodable	off-camera

**DAMAGED
TEXT
IN
ORIGINAL**

APPENDIX III: SAMPLE OF VIDEO TRANSCRIPT SHOWING OPEN CODING

6.30-
7.10

0.11 camera

(i) (ii) H goes	7:20 7:35	H1 shows K ball at pulleys. K reaches up and places ball in gutter. H explains activity K pulls on ropes, watches bucket go up (upside down) - pulls down again.	7:25 - 1:30 of camera Tries out what she has been told	2.7 2e	7.12 b
	7:45	off camera			X 7.4:
	8:29	K selecting rope, pulls ^{grn} one rope, bucket still upside down. ^{Ropes mixed out}	trying to sort	20	X 8.2
	8:42	moves off camera	Distracted by another activity	27	✓ 8.4
	8:55	Holding rope in one hand, places ball in gutter.		20	^ 8.5:
	9:20	Detaching/untangling ropes. Red rope has come off pulley, K tries to attach to bucket where green rope attached	Awareness of problem - tries to find solution	2j/k	f
(ii) but help needed - sufficing	9:40	H2 comes to help			X 9.1:
	10.00	H2 rethreads red rope - K holds green, waiting, takes red, uses to raise bucket, reaches up to bucket. K: Look (?) holds ^{fork} on bucket, H2 ^{fixing} rope. K pulls red, H2 ^{grn}	Non-verbal assistance, K waits, knows which rope she needs.	4d +	
	10.35	H2 suggests ball. K puts ball in, bucket tips, ball falls out.	Minimal verbal scaffolding	2i	
	10.45	H2: Green one tips it out. K raises bucket with red		4d +	e
	10:50	H2 moves away. ^{then by hand} K lowers bucket with ropes, places ball in gutter by hand, raises bucket again, places ball in gutter by hand, ball rolls onto floor.	Hasn't understood point or finding own solution?	?	
	11:50	K continues to hold rope, points to ball. K: There (?) (H2?) retrieves ball. K pulls both ropes, bucket tips, K pulls red rope only, bucket stays upright with ball. K tries to tip ball into gutter by hand - too high.			X 11.5
(iv)	12:10		Aware of why bucket has tipped? Able to remedy	2j/k	f
	12:26	Lowest bucket, takes ball out, throws towards gutter, holding fork on bucket, ball misses, falls on floor. K lowers bucket.	Losing patience? Trying new approach?	?	X 12.5
	13:50	K walks away? (Half off camera) ^{off camera}		20	X 14.1:
(i)	14:10	K watching at wind tunnel - LSA + Jo (?) LSA: Shall we show K? Look, K. K walks away. LSA: Come on K.	Learning by watching? Only input she has had on this apart from introduction.	2/c	b
	14:30	^{off camera}	Negative response to verbal attempt to get her to join in.	4a -	X 14.3
	14:50	K at skeleton, holds leg, moves it		2e	X 15.1
	15:10	Goes to look at wooden leg with Je + LSA LSA gives K string muscle, says 'Pull' K does so.		diver	d
	15:30	off camera		4a + 20	X 15.3

APPENDIX IV: SAMPLE OF VIDEO TRANSCRIPT SHOWING THEORETICAL CODING

14;10		<p> </p>	<p>K runs over to where Jo working at wind tunnel with LSA - watches as they finish putting card on car.</p> <p>LSA: <i>When you put it that way</i> (demonstrates shape of card)</p> <p>K watches car go down.</p> <p>LSA: <i>Watch</i> (points to eye)</p>	<p><i>Learning by watching? Only input she has had on this apart from introduction.</i></p> <p><i>Negative response to verbal attempt to get her to join in.</i></p>	b	10"	K
14;20		b → 2	<p>K takes car out of tunnel (back to front) makes to replace in tunnel.</p>		e	10"	Attempt to re-control
14;30		2 → b	<p>LSA takes car, places in tunnel.</p> <p>LSA: <i>Look, straight down. Watch</i></p>		b	10"	LSA takes control back
14;40		h → a	<p>K begins to move away.</p> <p>LSA (taking card off car) <i>Come on, K.</i></p> <p>K points at another activity (says going somewhere else?)</p> <p>LSA: <i>Come and see</i></p> <p>K: <i>No, no.</i></p> <p>Moves off camera</p>		a	5"	
					o	5"	K avoids camera
14;50	K at skeleton, holds leg, moves it				c	15"	
15;05	Goes to look at wooden leg with Je + LSA				b	15"	
15;20	LSA gives K string muscle, says 'Pull' K does so.	a -			d	10"	Follows direction, does it
15;30	off camera				o	35"	
16;05	K at motion sensor with LSA				b	5"	

APPENDIX V: COLOUR-CODED CHARTS 1: VISUAL SUMMARIES FOR ALL SESSIONS FOR FIVE MAIN PARTICIPANTS

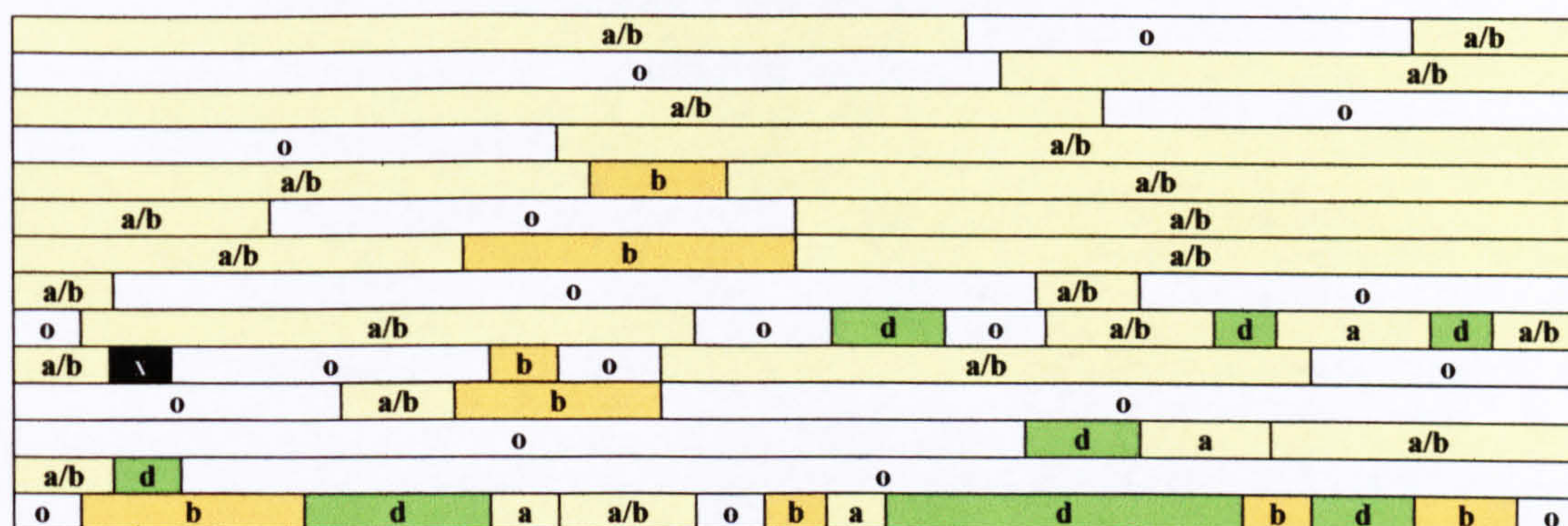
All video material for all sessions was colour-coded according to types of engagement with activities, as shown in the key, for the five main participants and set out along a timeline in order to build up a complete picture of each session (see Appendix II for operational definitions of codes).

Key:

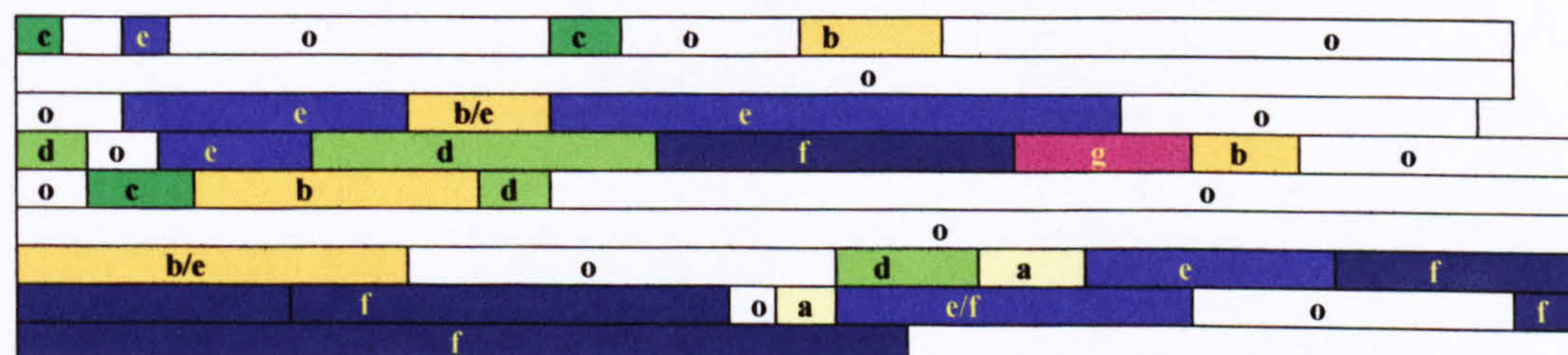
a	b	c	d	e	f	g
Not focused on activity	Initial interest	Playing/trying out	Following instructions	Working to goal	Making adjustments	Investigation/exploration

\	o
Uncodable	Off camera

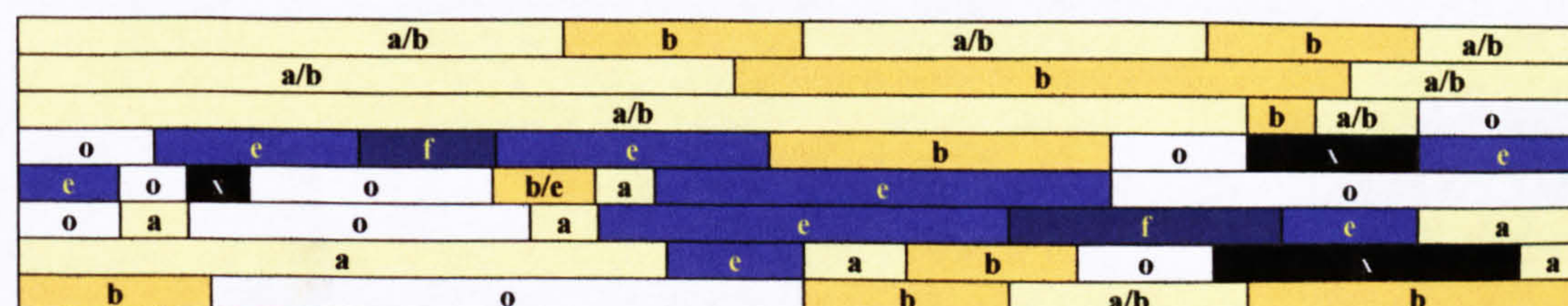
Alan - College session 1



Alan - ISC 1



Alan: Follow-up 1



b		x(c)							
x(c)				o	e				e
e	e/f	e	o	a/b	b	o			

Alan: College 2

a	d	b	a	d	b	a	d
d	a	d	a	d	a	d	a
a	d	d/e	d	a	d	a	a
a	b					d	a
a	d	b	a	a/b	d	d	d
d	d/e	a	d/e	d	b	d/e	d
d/e	b	d/e	a	d	d	d	d
d	o				d	a	b
b	d	o	x(d)		o	d/e	o
o	d	b	d	a	d	a	o

Alan: ISC 2

a	b	d	a	e	b	a	d	a
d	b	b	e	d	b	a	d	o
o	b	e	b	d	o	b	o	x
d	b	o	b	d	o	b	o	d
b	e	d	o	b/e	o	o	o	o
e	a	b	e	e	f	f	f	f
f	f	f	f	f	f	f	f	f
f	f	f	f	f	f	f	f	f
d	b	d	a	x	x	x	x	x
x	o	e	o	f	e	f	e	o
x	o	e	o	f	e	f	e	o
d	e	b	e	e	e	e	e	e
a	a	o	o	o	o	o	o	o
b	e	o	e	o	e	e	e	e
f	g	d	a	d	d	d	d	d
o	c/e	c/e	o	o	o	o	o	o
o	c/e	a	c/e	o	o	o	o	o

Alan: Follow-up 2

Discussion

a/b	b	a/b	b	a/b	b
Activities					
b	a/b	b	f	e/f	a
e/f	f	e/f	e	o	o
o	a/b	e	b	d	o
o	a	g	e	e	e
e	c	a	x	b	b/e
e/f	x	a/b	b	e	o

Gemma - ISC 1 (Preliminary study)

	a/b	o	a/b	x/b		o		x		o					
o															
	o	c/e	o	e	a		x	o	c/e	o	e	c/e			
c/e				o							a/b				
o		x(a/b)	o	x	o (x in glimpses)										
o															
	o						x	o	d/e			o			
o	b/e	d/e	o												
o											b	a			o
o					a/b	o	a								
a	o (d)		a	o							b	a	e		
e											x	o	x (a/b)		
o	a/b		a			o									
o															
o						x/b	b	a		o					
o	b	a/b													
a/b				o	b	d/e	x	a/b			x(a/b)				
x(a/b)															

Gemma - Follow-up 1 (Preliminary study)

Discussion

a	a/b
	a/b

Activities

a/b	b	e	
	e/f		e
	e	x	o
		e	
e	b	e/f	a
a	d/e	d/f	b/d
a	x	a/c	b/e
		d	a
			x

Gemma - College session 1

	x (a/b)	b	o	b	o
o		b	o	b	a/b
o		e	a/b	o	b/e
a/b		o		e	b
a/b	o	a	a/b		a/b
a/b	o	a/b	b/e	o	b/e
		b/e		b	
	b	o		a/b	
a/b	o	e	b		o
	o	b	a/b	b	o
d	o		a/b		d
d		o	a/b	o	a/b
		o	a		d/e
	a			o	
o	/b	o	d	d/e	d
d			o		
o		e		o	
d	o	e		o	

Gemma - ISC2

Introduction

b	o	a/b	b	o	a/b
---	---	-----	---	---	-----

Activities

o	b	o	e	o
o	e	e	b	o
o	a/b	d/e	o	
o	e	b		
o	b	o		
o	e	o		

Gemma - Follow-up 2

Discussion

b	a/b	o	a	o
o	a/b	b	a/b	b

Activities

o	b	e	a/b	x (b/e)	e	e/f
e	c/e	e	o			
o	b	o	e/f	e		
a	e	o	e	e/f	e	a
e	a	e	e/f	e	b	o
e	e/f	e	a	e/f	b	o
o	e	e/f	e			

Gemma - College 2

b	o	b	d	o	d/e	o
o	d/e	a/b	d	d/e		
d/e	d	b	o			
o	d	d/e	o	(d)e	o	
o	e	o	(d)e	o	(d)e	o
o	d	b	o	(d)e	o	
(d)e	o	a	d	a	d	

Gemma - ISC - 3

e	a	e	b	e	a
a	e	b	e		
e	f	e	b	o	
o	e	d/e	e		
e	e	b	e	e/f	
e/f	f	e/f	e	e/f	e
e	o	x	b	e	
o	b	d	e		
e	b	o			
o	o	b			
e	o	e	o	x	o

Gemma - Follow-up 3

Discussion										
a/b					a	a/b			b	a/b
Activities										
a/b	o	a/b	o	b	e	o				
						o	e			
e					a	e				
e						o				
						o	e			b
b	e		a		o					

Karen - ISC 1 (Preliminary study)

Introduction										
b	e			o	b	o	b		o	
o	b	o	b	o	b	e	b	o	b	o
Activities										
b					e			o		
o								e	\	o
o				e		o				
o						c		e	o	e/f
o										
o								e		
e	a	e		c/e	b	e	f	o		
o										
o	e				\	o				
o	e	c	o						c	
c/g		o	e		o					
Conference										
										o
e		o	b		o					
o					d/e					

Karen - Follow-up 1 (Preliminary study)

Discussion										
a/b										
b	b/e	a/b					b/e	a/b	a	a/b
a/b		b					o			
o								b		
Activities										
b		o		e					o	
o	e		e/f		d/e	e				
e	b			e	e/f		e	x(c)		
x(c)								e		
e										

Karen - School 1

a/b				a/b	b	a/b			o		a/b	o	a/b		
a/b								d	a	d					
										o		e		a/b	
a/b			d	e					d						
d				e					a				b		
a	o			b	a			o	a	o	b	a	b		
b		a	b	e					o		o				
o			c	b	o	e	x		b		o		b	o	b
o		b			a	o							a		
x		b			x		o		b	o		x			
x		o	a	o	x		a	e	o				x		
e		o													

Karen - ISC 2

	b	e				f		b	e				
e			f			e/f	e	o					
b	e	b	a	o	c	b	d	o	b	o	b	o	
o	b	e			f	e/f			e	f			
f					e/f								
	e/f		e	o	e	o	e		o	e			
	d	f/g		e/f			f	f/g		e	g		
f	g	a	o						e				
o			e	o			b	e		f/g			
f/g	g	f/g		g									
g	a	o	e		c/e	o							
o										e	o		
o	e	o											
o			f		o			e	o				

Karen - Follow-up 2:

a	e	o	e	f?	e	f	e	b	e	f	
f											
f					e						
f				e							f

Karen - School 2

The diagram illustrates the assembly of a 1000 bp DNA fragment from overlapping fragments labeled a, b, c, d, e, and e?. The fragments are represented as colored bars (yellow, green, blue) with labels indicating their size and overlap. The diagram shows how these fragments are joined to form a continuous sequence, with some fragments being used multiple times or in different orientations.

Karen - ISC 3

Karen - Follow-up 3

The diagram consists of several horizontal rows of colored blocks. The top row is yellow and contains the letters 'b', 'a', 'b', 'a', and 'o'. The second row is blue and contains 'e', 'o', 'e', 'o', 'f', 'o', and 'e'. The third row is blue and contains 'f/g', 'e', 'o', 'e', 'o', and 'g'. The fourth row is blue and contains 'e', 'o', 'e', 'o', 'f', and 'o'. The fifth row is blue and contains 'f' and 'o'. The sixth row is white and contains 'o' and 'e/g'. The seventh row is green and contains 'at least C'. The eighth row is pink and contains 'g'.

Bill ISC 1 (preliminary study)

o	a/b	o	b	o	b	o	b	b/d	b
o	b	o	a/b	o	b	o	b	a	o
o	b	o	a/b	o	b	o	b	o	b
e	a	o	o	o	e	e/f	o	o	e
e	o	o	e	o	e	o	e	b	e
o	b	o	b	e	o	e	o	e	a
e	b	o	o	o	b	o	b	g	e
g	o	b	o	o	o	b	o	e	e
o	o	o	e	o	b	e	o	o	o
o	e/f	o	o	e/f	e	e	e	e	e
e	a	o	e	g	o	e	g	a	e
o	o	o	o	o	o	o	o	o	o
o	e	o	o	o	o	o	o	o	o

'Conference'

o	a/b	o	a/b	o	a/b	o	o
o	b	a/b	o	a/b	o	b	o
a/b	o	a/b	o	o	o	o	o

Bill - School 1

a/b	o	a/b	o	a/b	d	b	o
o	a/b	o	a/b	o	b	o	o
o	a/b	o	a/b	o	o	o	d/e
d/e	b	o	a	o	b	e	b
a/b	b	a/b	o	a/b	a	o	o
o	o	a/b	o	d	a/b	o	o
a/b	d	b	o	o	a/b	b	o
b	a/b	b	a/b	o	b	o	a/b
a/b	b/e	o	b	o	b	a/b	b
o	b	o	b	o	b	o	o
o	o	a/b	o	b/e	o	o	o
d/e	o	d/e	o	o	o	o	o

Bill - ISC 2

b	o	e	o	e	o	e	e/f
e/f	e	e/f	b	c	b	o	o
e	e/f	e	e/f	o	o	o	o
b	e	e	e	e	e	e	e

b	e	c/e	e	e	e	e	e
e	e/f	e	e	e	e	e	e
e	e/g	e	e/f	g	e	e	e
g	o	o	e	e	e	e	e
c	o	o	e	c	f/g	g	e
g	o	o	o	o	o	o	o
o	o	c/g	c/g	c	a	e	a
c/g	c	d/e	e/f	a	e	e	e
e	e	e	a	e	e	e	e
e	a	e	e/f	a	e	e	e
e	e	e	e	e	e	e	e

Bill - Follow-up 1

b			a		b	e	e/f	e	e/f
e/f	e	e/f	e						
b	o		e	o	e				∖ (e)
e	b		e	a	c/e				a
a	∖	o	∖	c	e	e/f	b	d	c/e
e/f	e					g?	c/g		

Michael - School 1

o	a	b	o			a	o		a	b	
a				o	b/e				b	a/b	
a/b							o				
o	b	o	b	o	a					∖	
∖	a	o			e	a/b	o				
o						d	o				
o	a	o	d	a	a/b	a				a/b	
a/b		b		a/b			d/e	b	a/b		
a/b			b	a/b		b	a/b				
a/b		b?			a/b						b
b	a/b	a	a/b		a		d				

Michael - ISC 1

o	a	o	a/b	b	o				b	o	b	o	a/b	
a/b	o													
o	e		o											
o					a/c	c		o	c	a/c				
a/c					o	a/c	b			o				
o					b			o			a/c	o		
o					o					c	b	o	b	o
o	e	e/f						a/c	c	b	o			
o							g							
a/b										a/b				
a/b		o										a/c		
a/c		b			a	o	b	a/c			o			
o							b			o	g			
g			f		a/c					o				

Michael - Follow-up 1

b			o	a	a/b	b	o		a	b	o
e	b	a	b	o	a/b	b	c/e		e	c	a/b
b	a	o	∖		a	b/c	e	o	d/e	o	a
a	b/e	a	d	o	a	b	e	b	a	o	a

Michael - School 2

										o		a					
										a							
a					b		a					b		d	o	d	
d															a/b		
b/e		a/b					b/e			a/b							
a/b		a			a/b							b		c			
e			b			a/b			a					b			
b	a/b					e			d	a/b							
a/b	o					a/b							d				
d					a/b												
										a/b							
a/b		d/e										b					

Michael – ISC 2

a/c	o	b	e	o	c				d	a	c	o	a/c	o	
o					c				\	c	d	o			
o	c				b	\	c	a/c	b	a/c				c	
c	a/c				b/c	a/c			o	a/c					
a/c					a	\	a/c				b/c	a/c			
a/c	\				b	a/c				o			a/c		
a/c	a	\				O					a/c				o
a/c				a	a/c	b	a/c	a	b	o	b	a			
b	\	b			o	b/c					o	c			
c					b			c				a	c		
c	o	a/c			b	o	b			o	a/b	o	a/b		

Michael - Follow-up 2

e									
e	o	e						o	b/e
b/e									

APPENDIX VI: COLOUR-CODED CHARTS 2: CHARTS SHOWING SEQUENTIAL ANALYSIS FOR ISC VISITS FOR FIVE MAIN PARTICIPANTS

Key:

a	b	c	d	e	f	g
Not focused on activity	Initial interest	Playing/ trying out	Following instructions	Working to goal	Making adjustments	Investigation/ exploration

x	o
Uncodable	Off camera

Sequential Analysis:

For the five main participants interactions with other people were mapped onto the coloured timeline charts for ISC visits in order to permit a form of sequential analysis designed to look at the effect of these interventions.

Key to interactions:

- i) verbal input, other takes control**
- ii) non-verbal input, other takes control**
- iii) verbal input, student maintains control**
- iv) non-verbal input , student maintains control**

Gemma - ISC 1 (Preliminary study)

End of Demonstration

Activities

Marble Run

0;0 10 20 30 40 50 1;0 10 20 30 40 50 2;0 10 20 30 40 50 3;0 10 20 30 40 50 4;0

4;0 10 20 30 40 50 5;0 10 20 30 40 50 6;0 10 20 30 40 50 7;0 10 20 30 40 50 8;0

8;0 10 20 30 40 50 9;0 10 20 30 40 50 10;0 10 20 30 40 50 11;0 10 20 30 40 50 12;0

Water-lift

12;0 10 20 30 40 50 13;0 10 20 30 40 50 14;0 10 20 30 40 50 15;0 10 20 30 40 50 16;0

Heated House

16;0 10 20 30 40 50 17;0 10 20 30 40 50 18;0 10 20 30 40 50 19;0 10 20 30 40 50 20;0

20;0 10 20 30 40 50 21;0 10 20 30 40 50 22;0 10 20 30 40 50 23;0 10 20 30 40 50 24;0

24;0 10 20 30 40 50 25;0 10 20 30 40 50 26;0 10 20 30 40 50 27;0 10 20 30 40 50 28;0

Wind Generator

28;0 10 20 30 40 50 29;0 10 20 30 40 50 30;0 10 20 30 40 50 31;0 10 20 30 40 50 32;0

32;0 10 20 30 40 50 33;0 10 20 30 40 50 34;0 10 20 30 40 50 35;0 10 20 30 40 50 36;0

Marble Run

36;0 10 20 30 40 50 37;0 10 20 30 40 50 38;0 10 20 30 40 50 39;0 10 20 30 40 50 40;0

Breathing Skeleton

40;0 10 20 30 40 50 41;0 10 20 30 40 50 42;0 10 20 30 40 50 43;0 10 20 30 40 50 44;0

Water-lift Circuits

44;0 10 20 30 40 50 45;0 10 20 30 40 50 46;0 10 20 30 40 50 47;0 10 20 30 40 50 48;0

48;0 10 20 30 40 50 49;0 10 20 30 40 50 50;0 10 20 30 40 50 51;0 10 20 30 40 50 52;0

i i stops

o	a/b	a			o
---	-----	---	--	--	---

52;0 10 20 30 40 50 53;0 10 20 30 40 50 54;0 10 20 30 40 50 55;0 10 20 30 40 50 56;0

o

56;0 10 20 30 40 50 57;0 10 20 30 40 50 58;0 10 20 30 40 50 59;0 10 20 30 40 50 60;0

o	x/b	b		a	o
---	-----	---	--	---	---

60;0 10 20 30 40 50 61;0 10 20 30 40 50 62;0 10 20 30 40 50 63;0 10 20 30 40 50 64;0

'Conference'

o	b		a/b
---	---	--	-----

0;0 10 20 30 40 50 1;0 10 20 30 40 50 2;0 10 20 30 40 50 3;0 10 20 30 40 50 4;0

a/b	o	b	d/e	x	a/b	x(a/b)
-----	---	---	-----	---	-----	--------

4;0 10 20 30 40 50 5;0 10 20 30 40 50 6;0 10 20 30 40 50 7;0 10 20 30 40 50 8;0

x(a/b)

8;0 10 20 30 40 50 9;0 10

Gemma - ISC2

Introduction

i

b	o	a/b	b	o	a/b
---	---	-----	---	---	-----

0;0 10 20 30 40 50 1;0 10 20 30 40 50 2;0 10 20 30 40 50 3;0 10 20 30 40

Activities

Dominoes

iii + iv

o	b	o	e	o
---	---	---	---	---

40 50 4;0 10 20 30 40 50 5;0 10 20 30 40 50 6;0 10 20 30 40 50 7;0 10 20

iv ->

o	e	e
---	---	---

20 30 40 50 8;0 10 20 30 40 50 9;0 10 20 30 40 50 10;0 10 20 30 40 50 11.0

iv ->

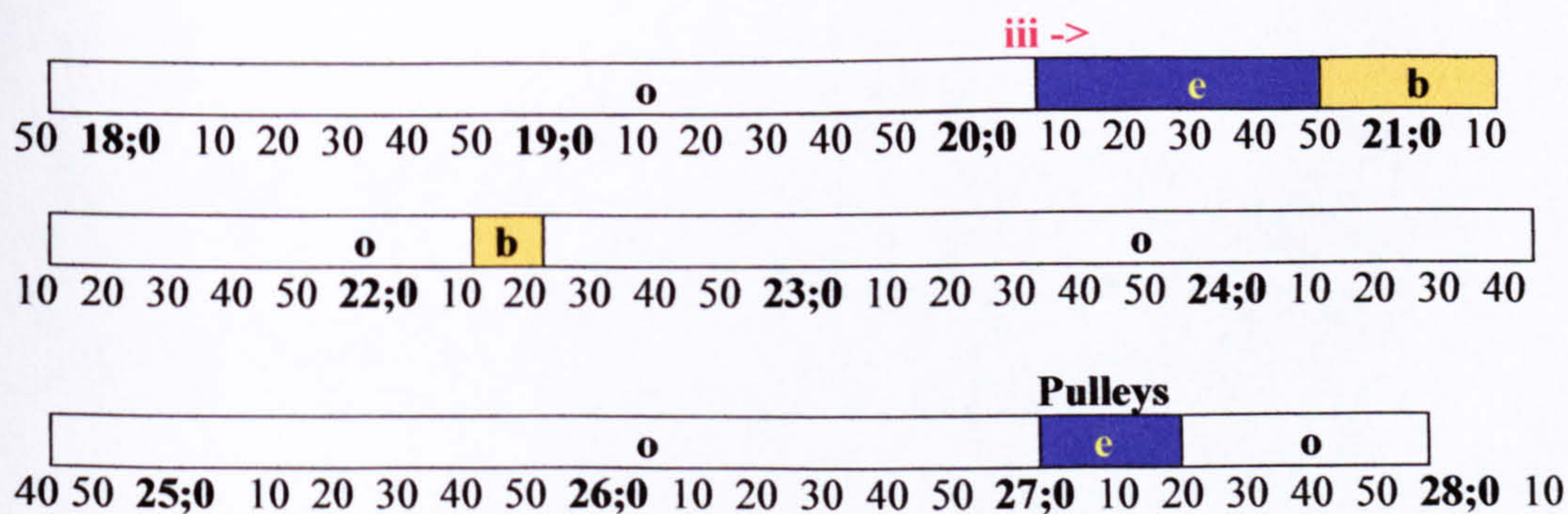
e	b	o
---	---	---

11;0 10 20 30 40 50 12;0 10 20 30 40 50 13;0 10 20 30 40 50 14;0 10 20

ii + i

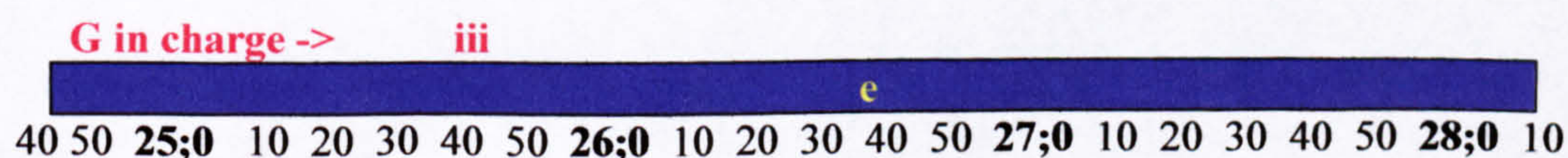
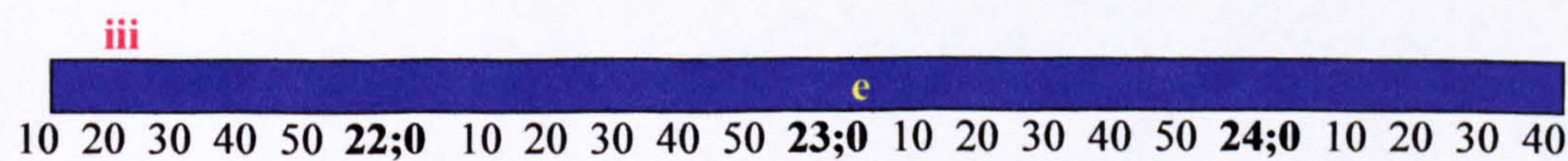
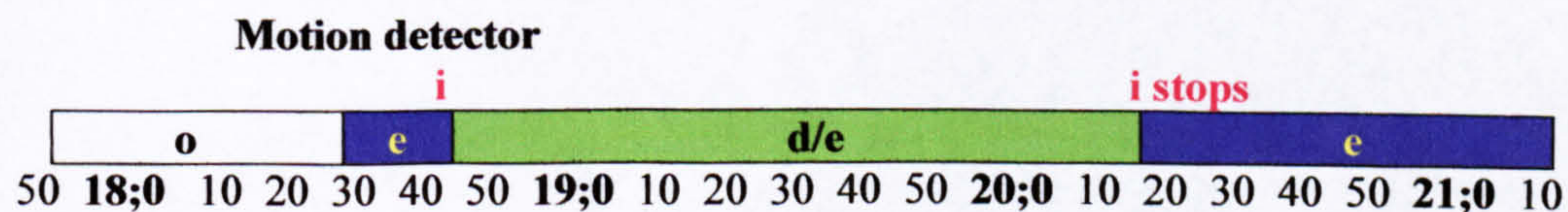
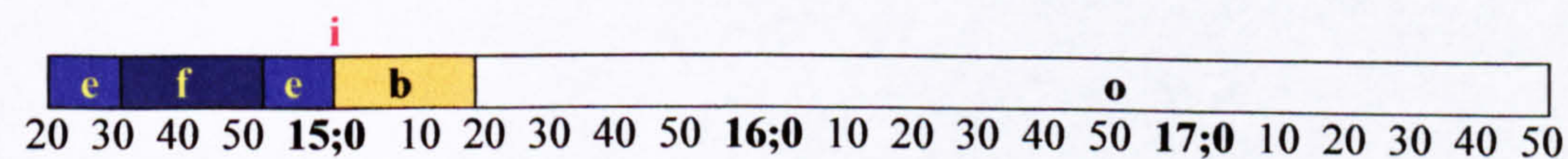
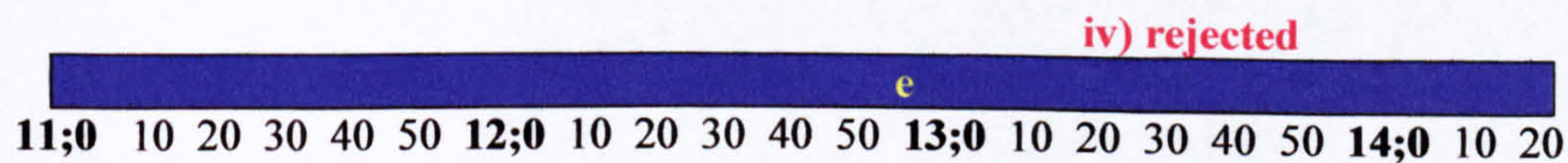
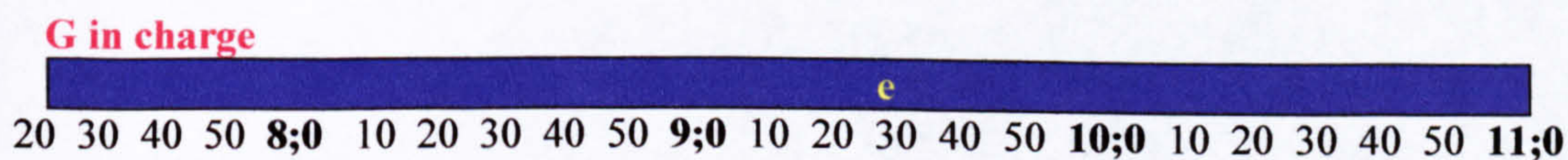
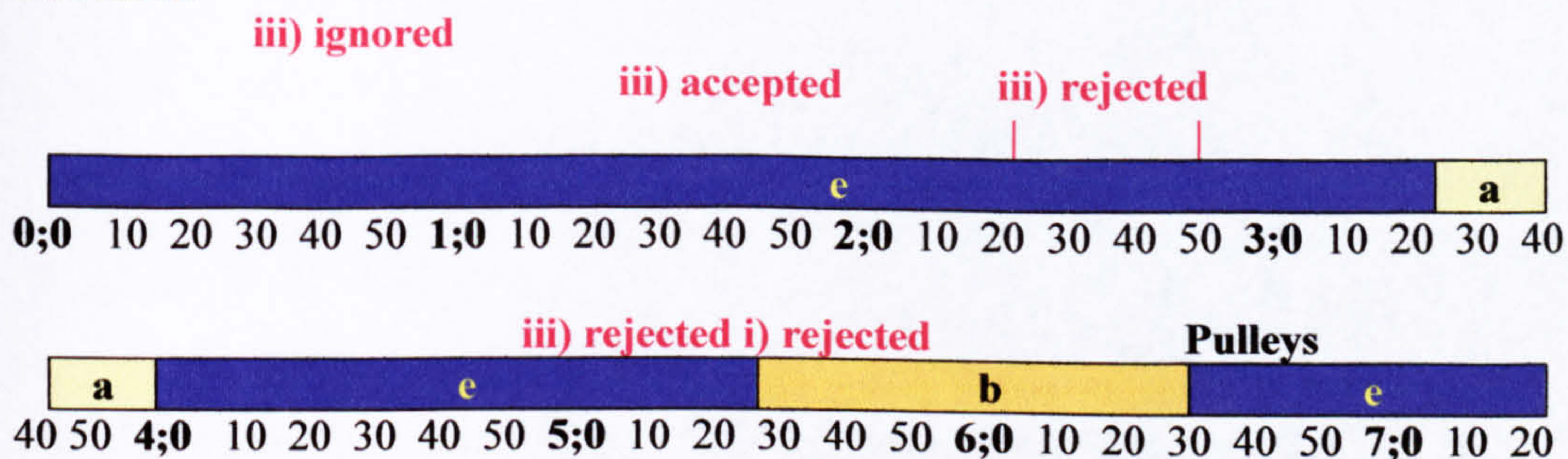
o	a/b	d/e	o
---	-----	-----	---

20 30 40 50 15;0 10 20 30 40 50 16;0 10 20 30 40 50 17;0 10 20 30 40 50

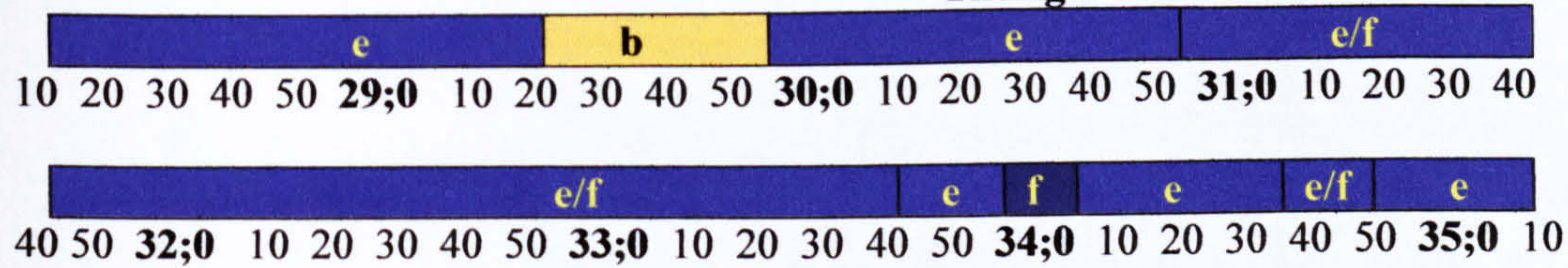


Gemma ISC 3

Dominoes



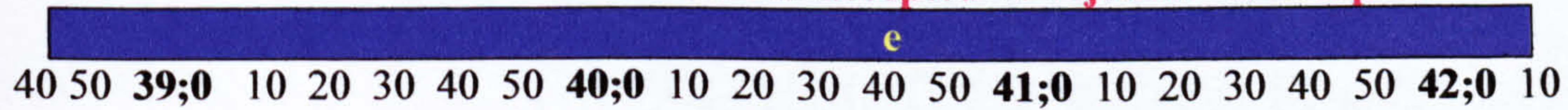
Tilting Gutter



Pulleys

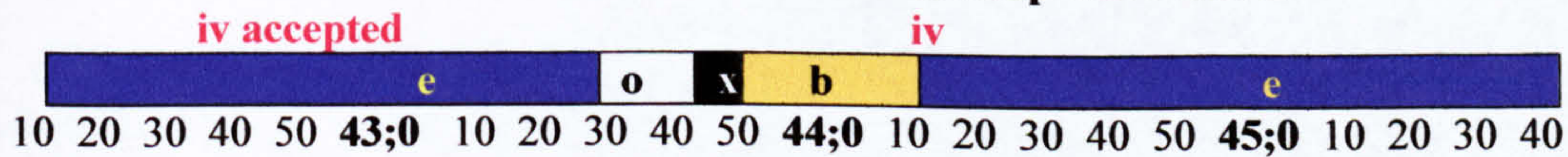


iii + iv accepted iv rejected iv accepted



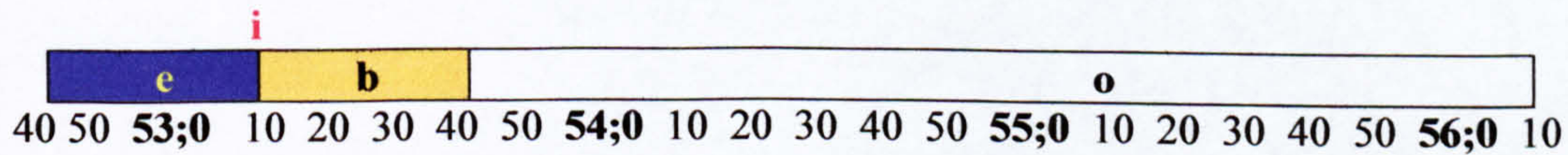
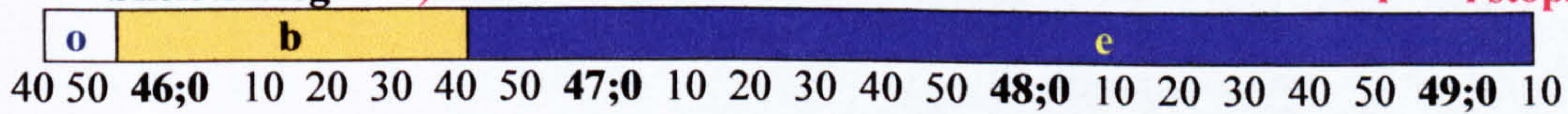
Magnet

Thump-wave clown

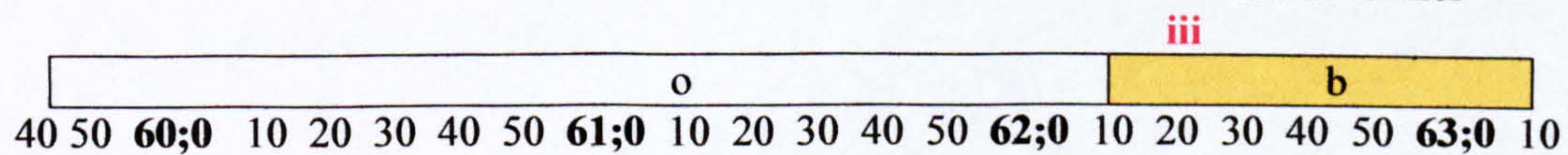


Skeleton/leg iii)

i i stops



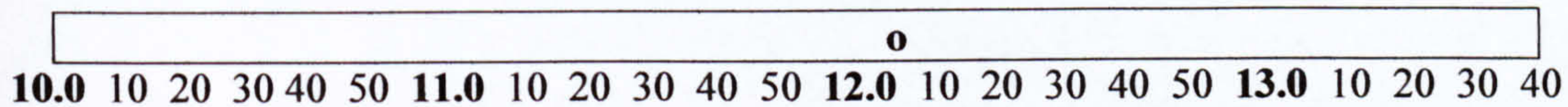
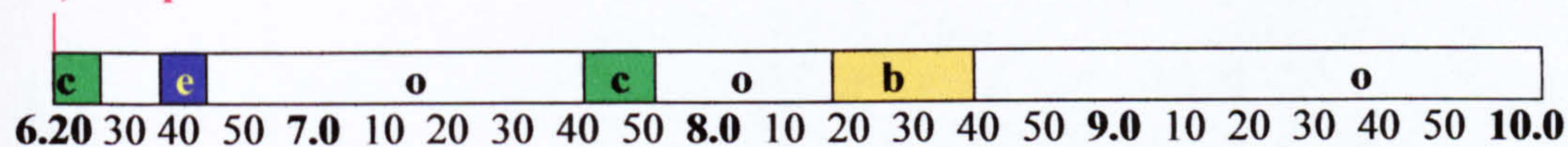
Wind tunnel



Alan - ISC 1

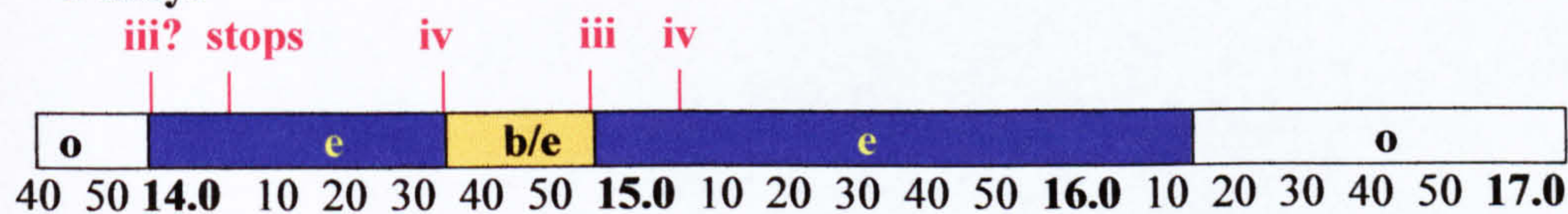
Water-lift

i)? stops

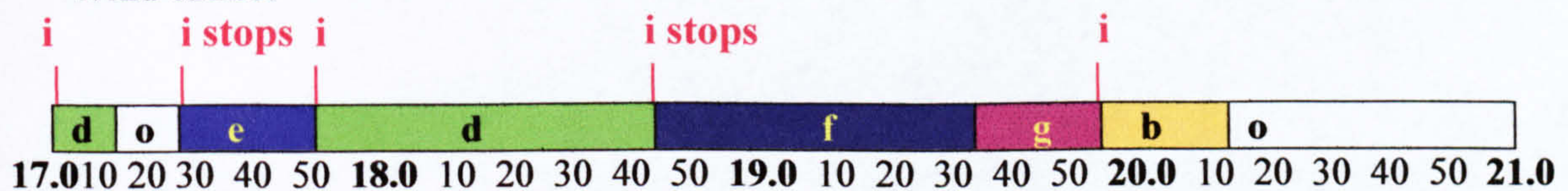


Pulleys

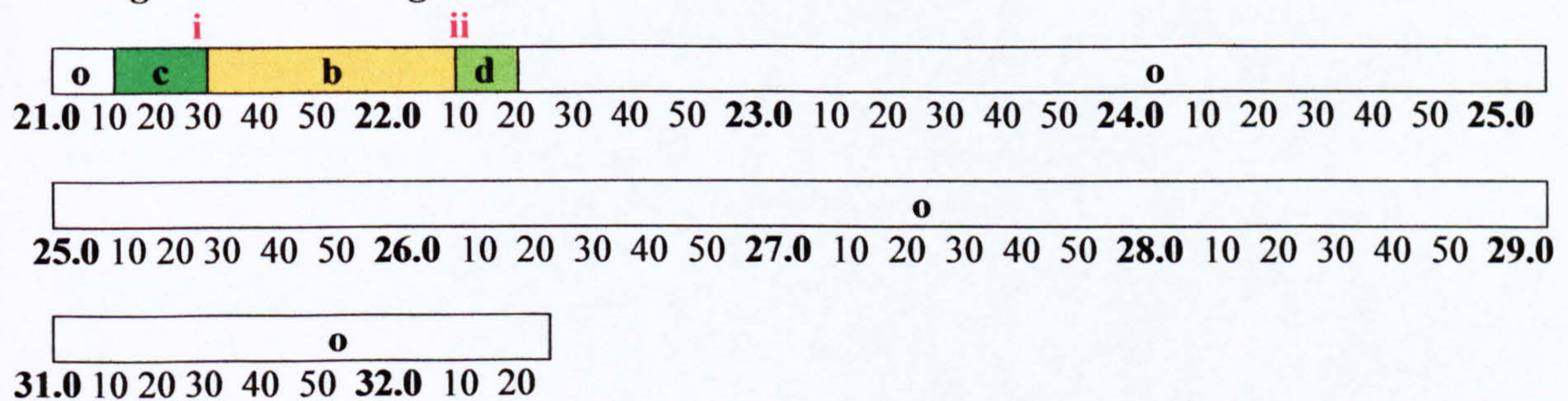
iii? stops



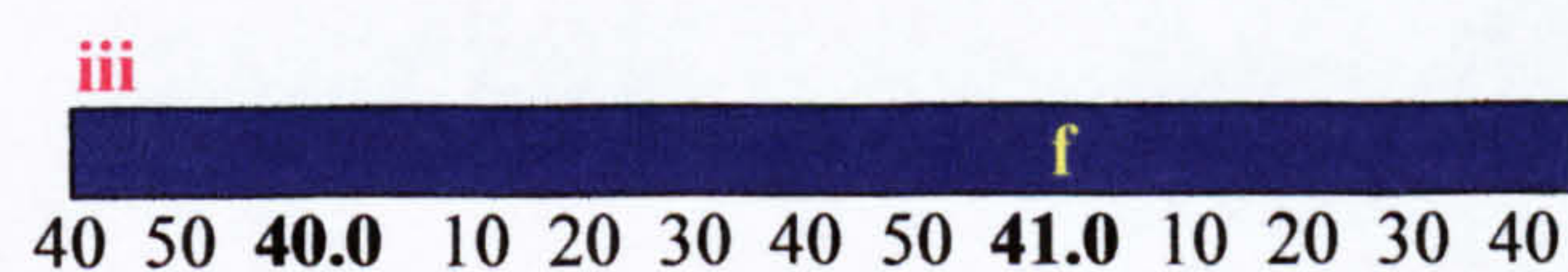
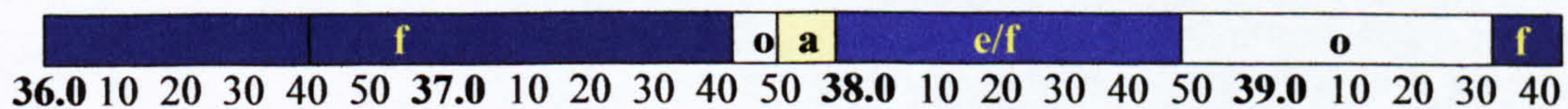
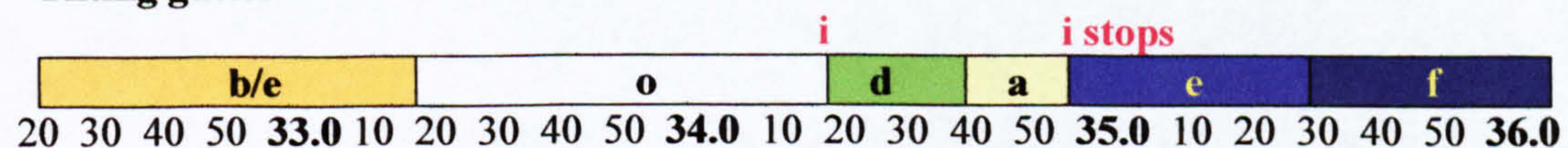
Wind tunnel



Leg Dominoes Leg Dominoes

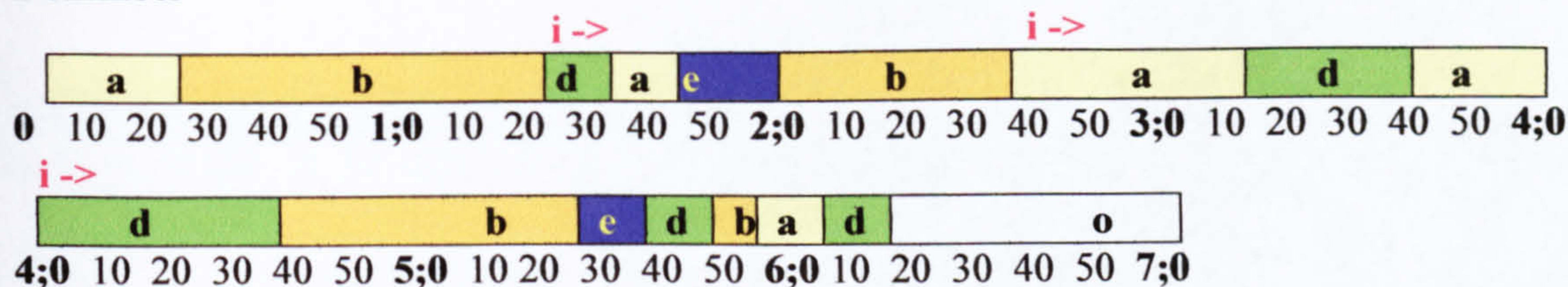


Tilting gutter

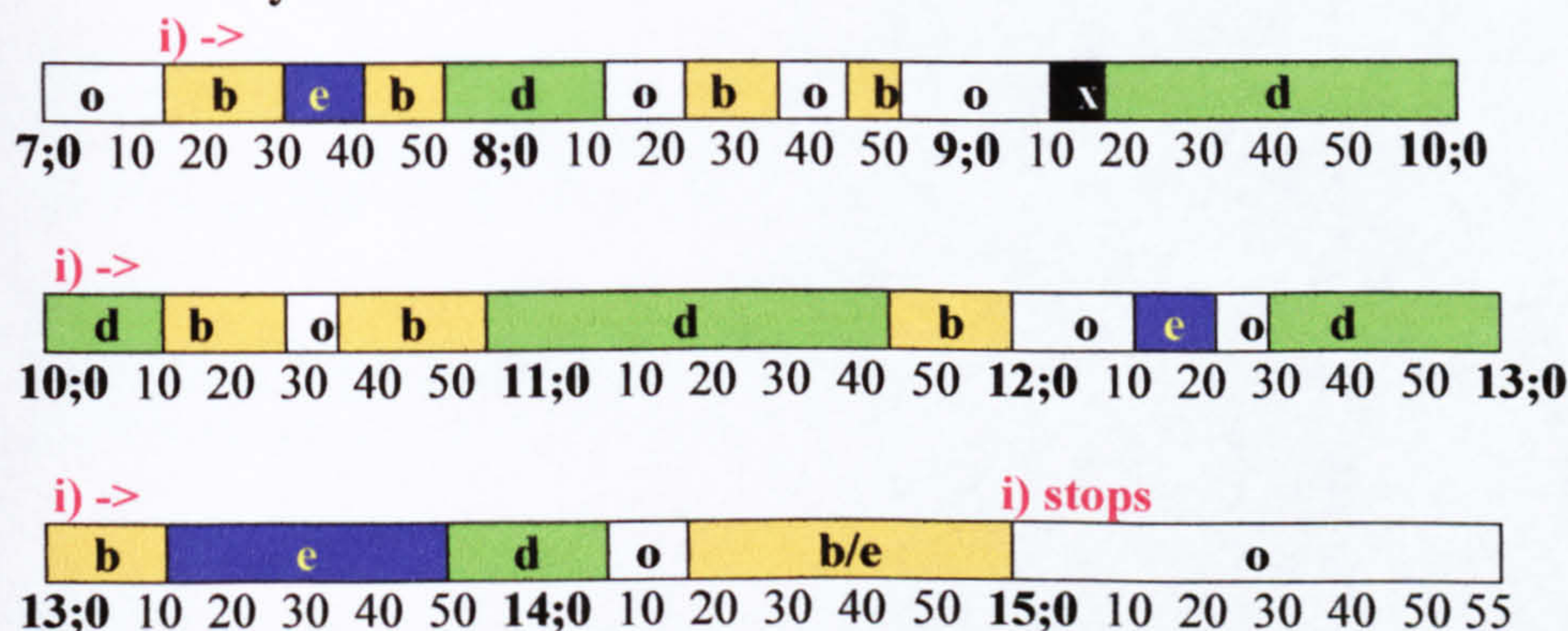


Alan: ISC 2

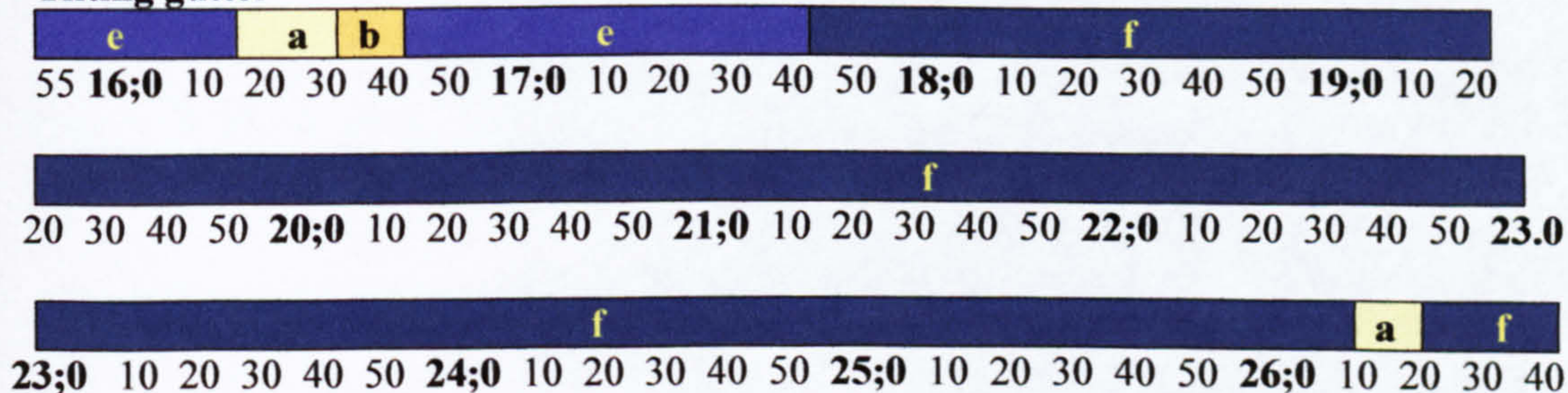
Dominoes



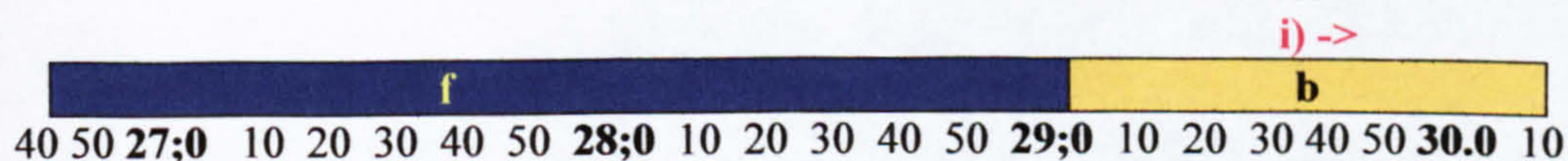
Pulleys



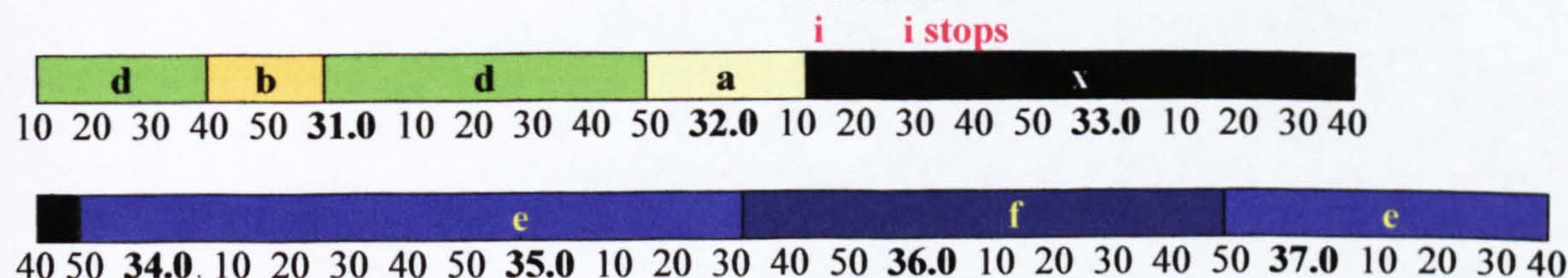
Tilting gutter



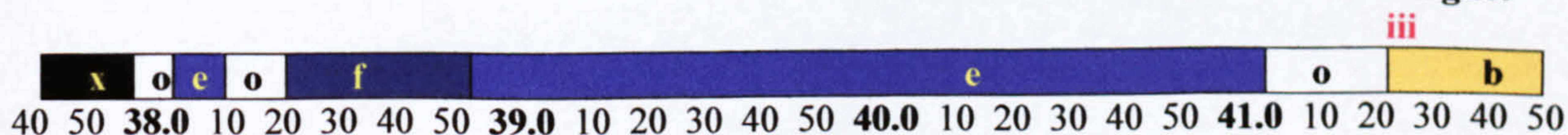
Motion Detector

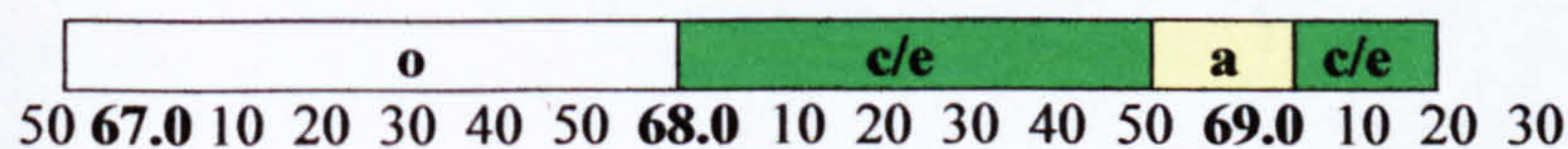
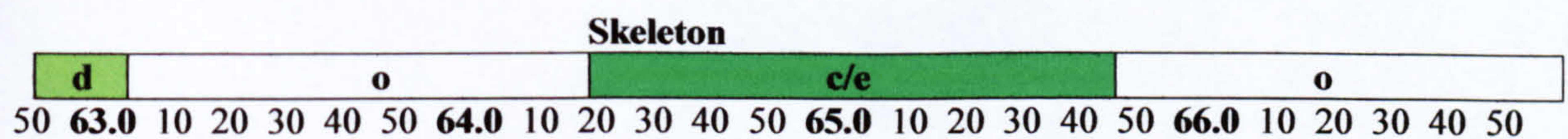
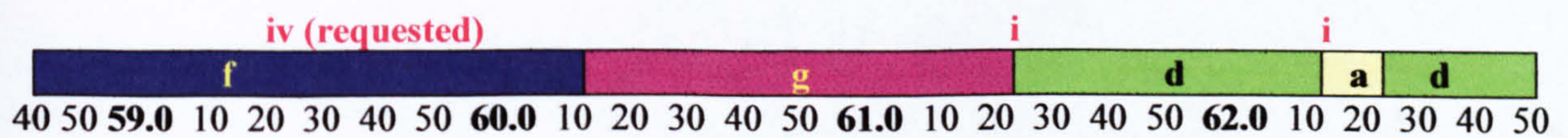
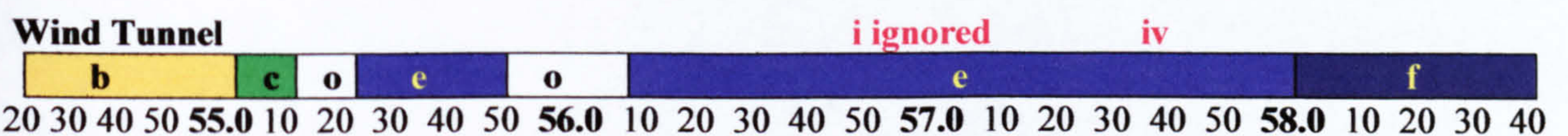
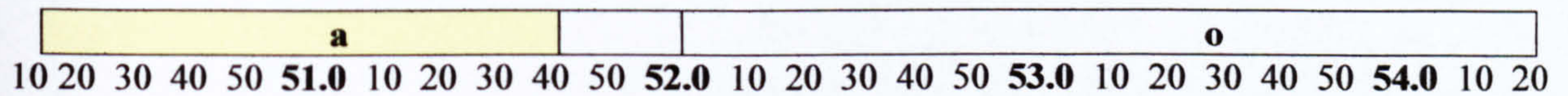
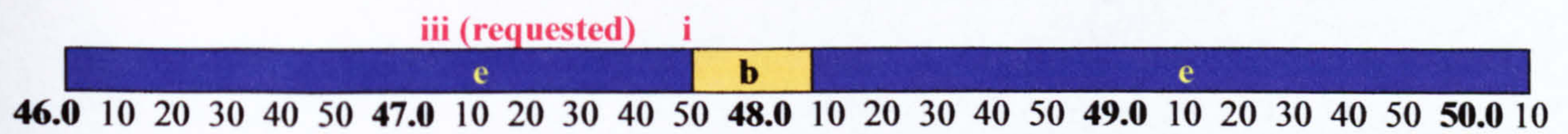
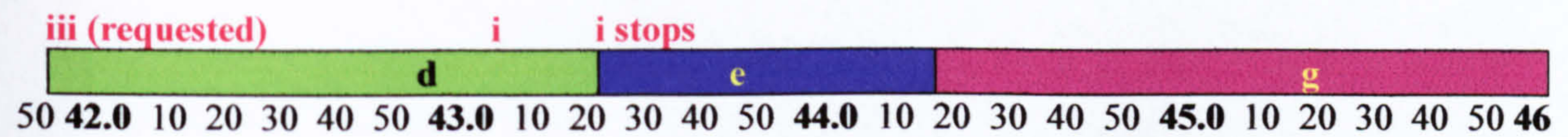


Dominoes



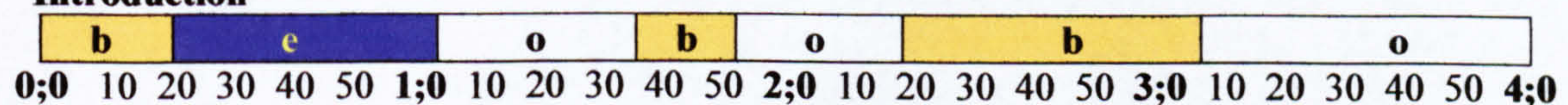
Magnet



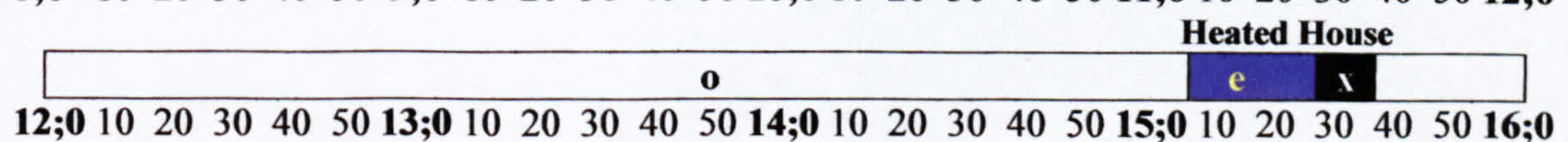
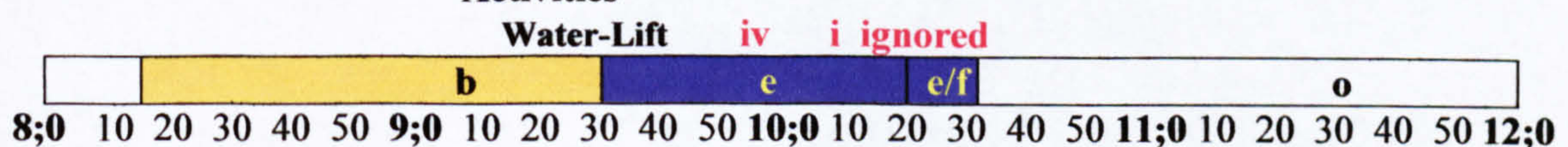


Karen - ISC 1 (Preliminary study)

Introduction



Activities



o e o

16;0 10 20 30 40 50 17;0 10 20 30 40 50 18;0 10 20 30 40 50 19;0 10 20 30 40 50 20;0

Wind Generator House

o c e o e/f

20;0 10 20 30 40 50 21;0 10 20 30 40 50 22;0 10 20 30 40 50 23;0 10 20 30 40 50 24;0

o

24;0 10 20 30 40 50 25;0 10 20 30 40 50 26;0 10 20 30 40 50 27;0 10 20 30 40 50 28;0

Water-Lift

iv

o e

28;0 10 20 30 40 50 29;0 10 20 30 40 50 30;0 10 20 30 40 50 31;0 10 20 30 40 50 32;0

iii ii rejected

iv iv/iii

iii ii rejected

iii

e a e c/e b e f o

32;0 10 20 30 40 50 33;0 10 20 30 40 50 34;0 10 20 30 40 50 35;0 10 20 30 40 50 36;0

o

36;0 10 20 30 40 50 37;0 10 20 30 40 50 38;0 10 20 30 40 50 39;0 10 20 30 40 50 40;0

iii

o e λ o

40;0 10 20 30 40 50 41;0 10 20 30 40 50 42;0 10 20 30 40 50 43;0 10 20 30 40 50 44;0

ii resisted

iv

o e c o c o

44;0 10 20 30 40 50 45;0 10 20 30 40 50 46;0 10 20 30 40 50 47;0 10 20 30 40 50 48;0

iv

o c/g o e o

48;0 10 20 30 40 50 49;0 10 20 30 40 50 50;0 10 20 30 40 50 51;0 10 20 30 40 50 52;0

The diagram shows three horizontal bars representing the distribution of vowel segments in the word 'obedient' across 100 segments. The segments are numbered 0 to 100 in increments of 10.

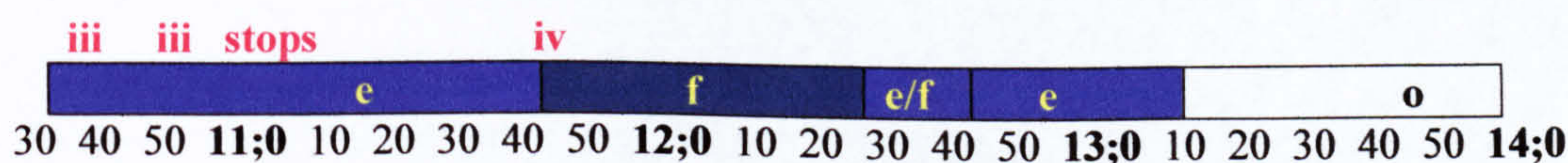
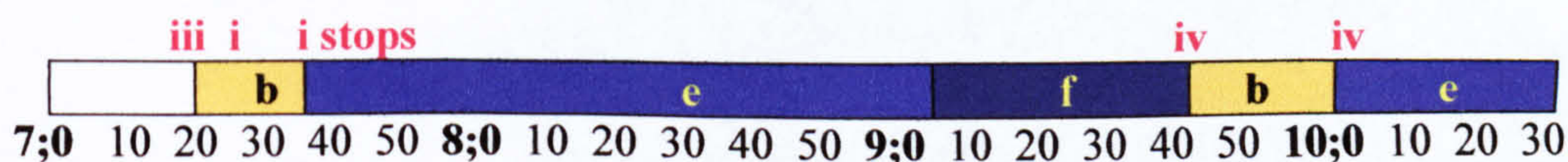
- Bar 1 (Top):** Shows the distribution of the vowel 'o'. It is present in segments 10-50 (50 segments) and 60-90 (30 segments), totaling 80 segments.
- Bar 2 (Middle):** Shows the distribution of the vowel 'e'. It is present in segments 0-10 (10 segments). The vowel 'b' is present in segments 40-50 (10 segments). The vowel 'o' is present in segments 10-40 (30 segments) and 60-90 (30 segments), totaling 60 segments.
- Bar 3 (Bottom):** Shows the distribution of the vowel 'd/e'. It is present in segments 0-50 (50 segments) and 60-70 (10 segments), totaling 60 segments.

Karen - ISC 2

0-6.30 Introduction

6.30-7.10 off camera

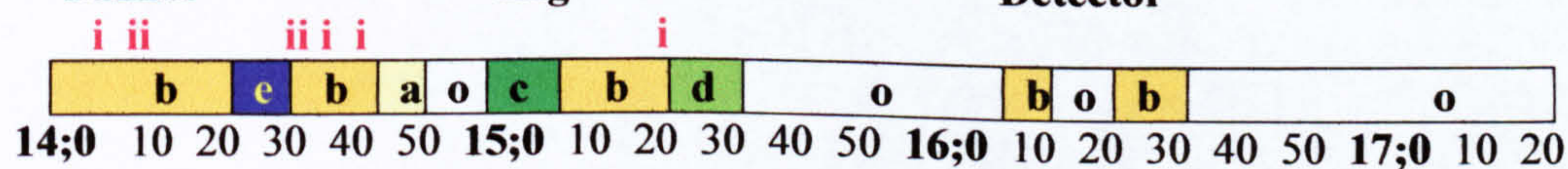
Pulleys



Wind Tunnel

Skeleton + Leg

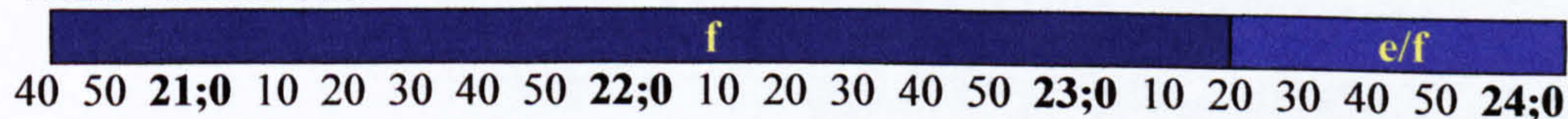
Motion Detector



Magnet to Wind tunnel

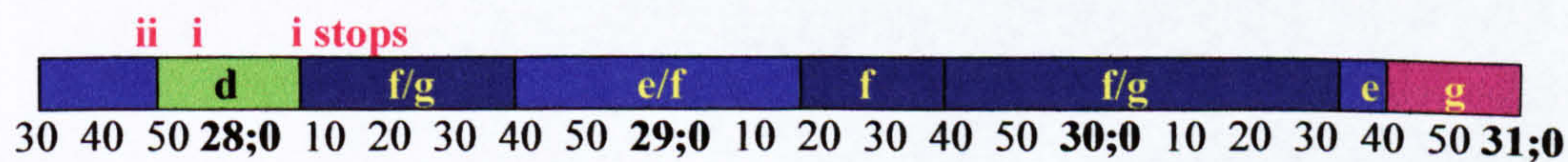
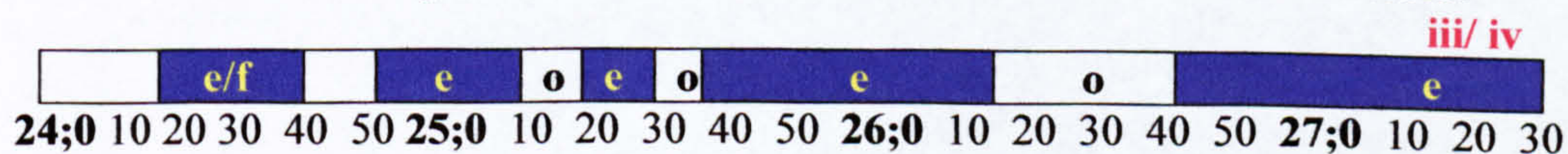


Wind tunnel cont

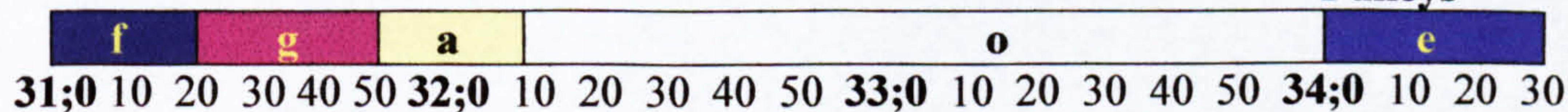


Dominoes Leg

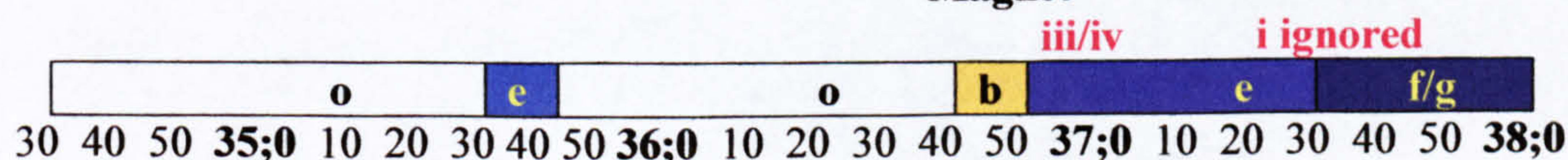
Motion Detector



Pulleys



Magnet



f/g g f/g g
38;0 10 20 30 40 50 39;0 10 20 30 40 50 40;0 10 20 30 40 50 41;0 10 20 30 40

Motion Detector Leg
iii/iv iii/iv
g a o e c/e o
40 50 42;0 10 20 30 40 50 43;0 10 20 30 40 50 44;0 10 20 30 40 50 45;0 10

o e o
10 20 30 40 50 46;0 10 20 30 40 50 47;0 10 20 30 40 50 48;0 10 20 30 40 50

o e o
50 49;0 10 20 30 40 50 50;0 10 20 30 40 50 51;0 10 20 30 40 50 52;0 10 20 30

Pulleys
iv
o f o e o
30 40 50 53;0 10 20 30 40 50 54;0 10 20 30 40 50 55;0 10 20 30 40 50 56;0 10

Karen - ISC 3

0-1.15 Demonstration

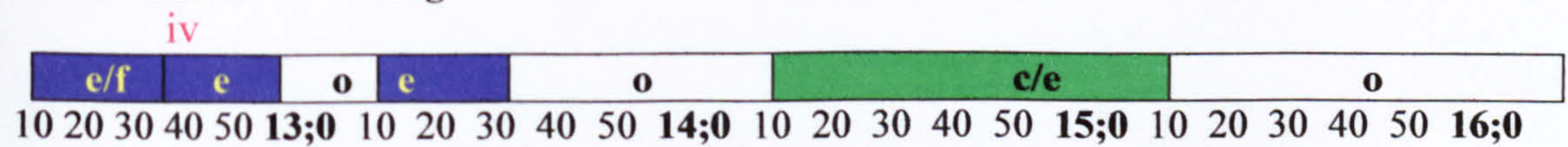
Pulleys
iii iii i ignored iv
o e e/f x/c e f e/f e o e/f
1;0 10 20 30 40 50 2;0 10 20 30 40 50 3;0 10 20 30 40 50 4;0 10 20 30 40 50

Magnet Tilting gutter
i ignored iii i ignored i ignored
e o c e f o e f
50 5;0 10 20 30 40 50 6;0 10 20 30 40 50 7;0 10 20 30 40 50 8;0 10 20 30

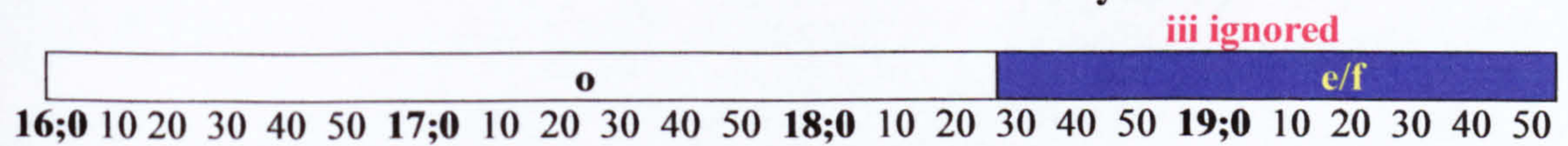
Motion Detector Thump Wave
i ignored iv iv requested
f e o e d f e x o
30 40 50 9;0 10 20 30 40 50 10;0 10 20 30 40 50 11;0 10 20 30 40 50 12;0 10

Wind Tunnel

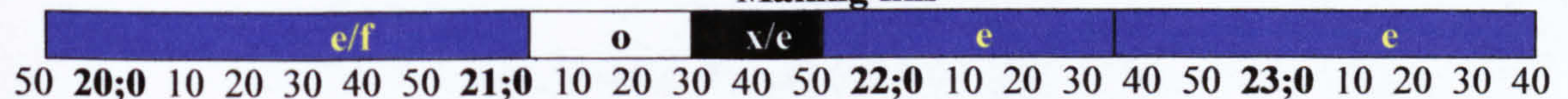
Leg



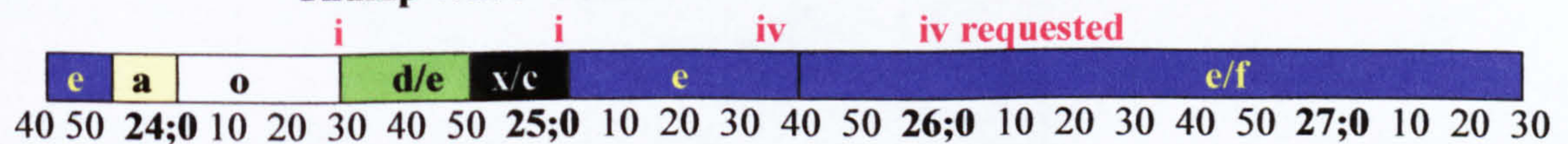
Pulleys



Making fins



Thump Wave Dominoes

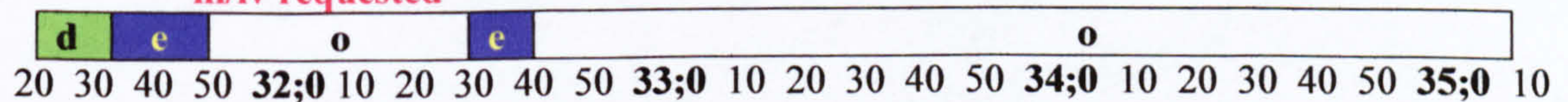


Thump Wave

Skeleton Leg

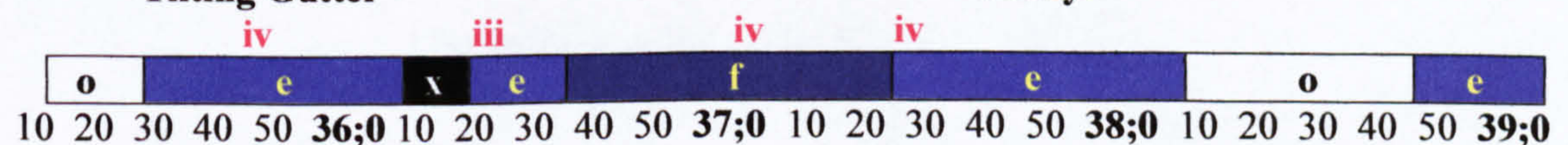


iii/iv requested

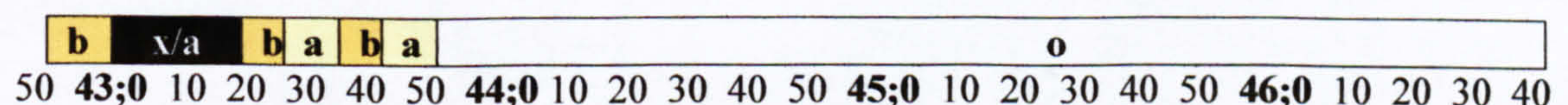


Tilting Gutter

Pulleys



Fish

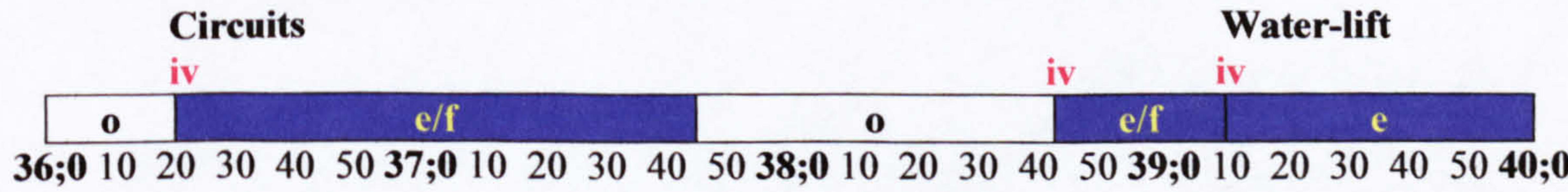
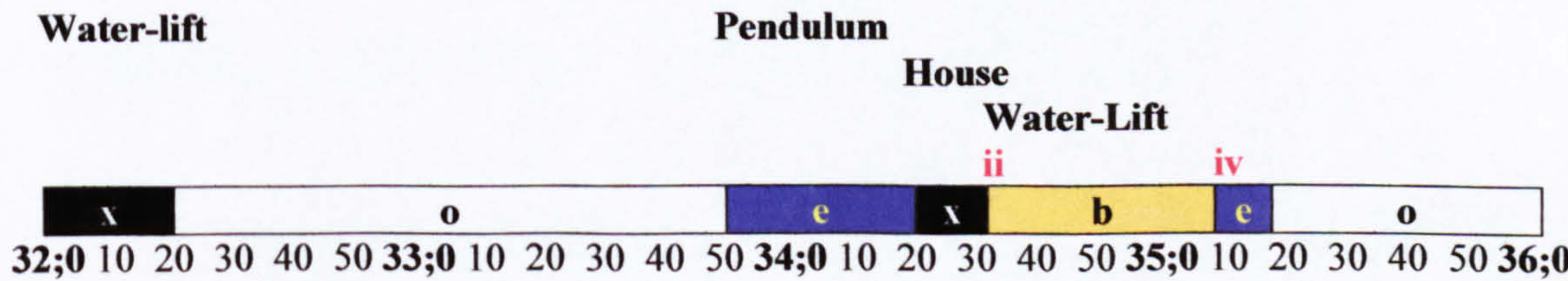
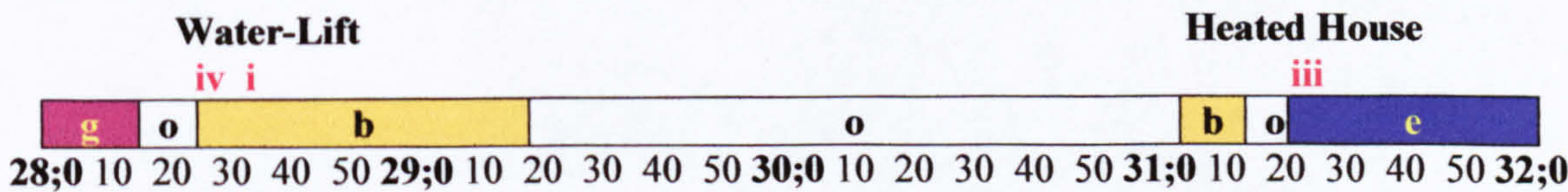
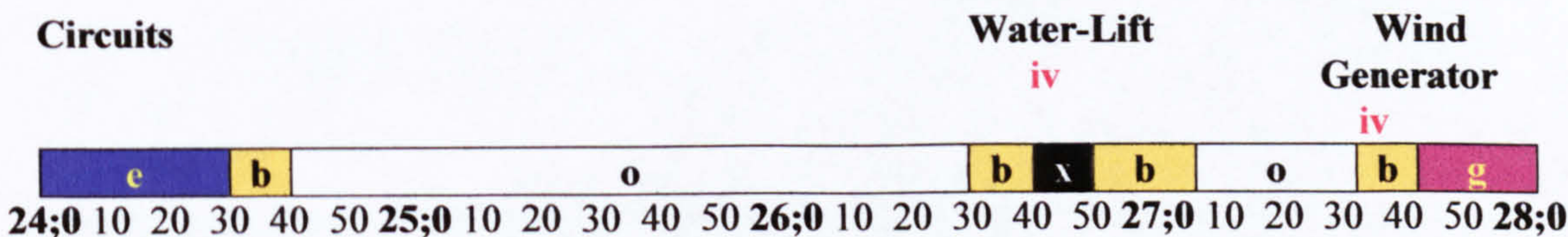
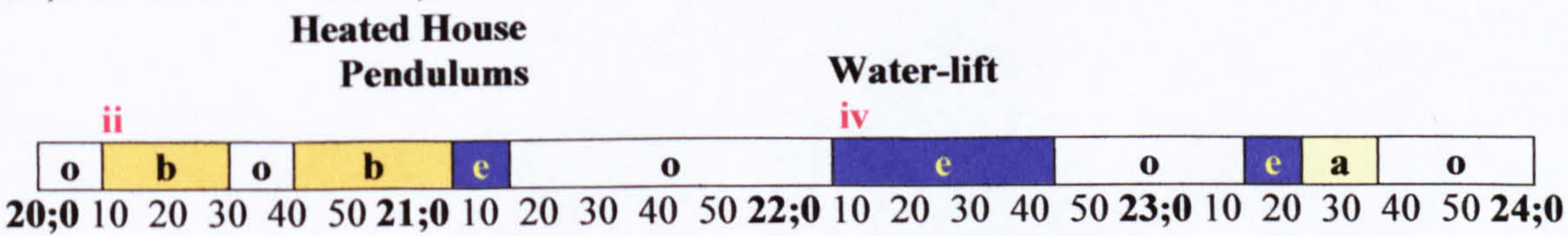
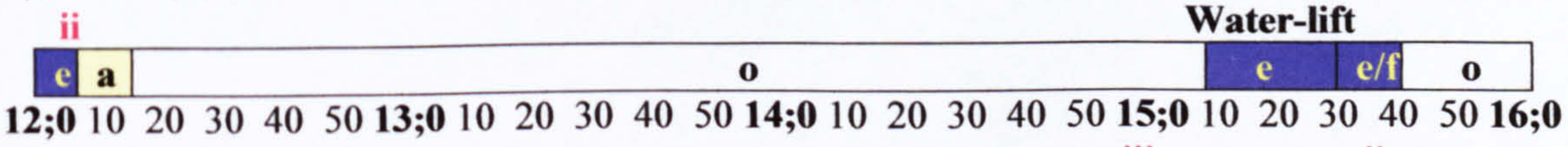
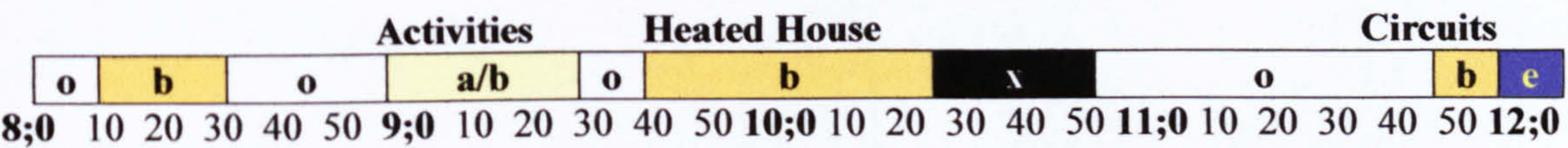
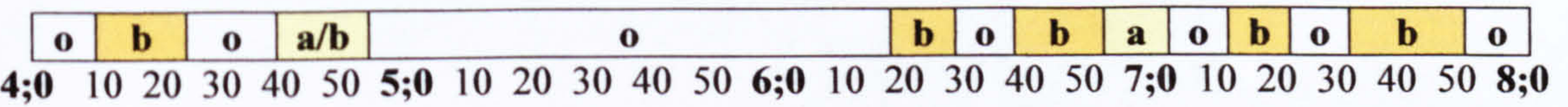
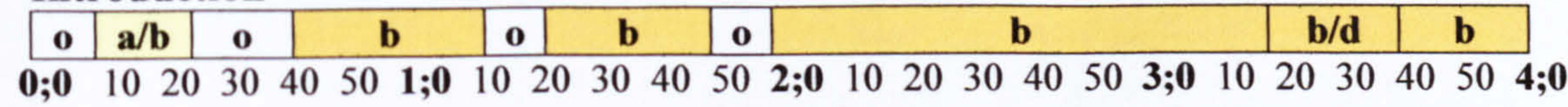


Pulleys



Bill ISC 1 (Preliminary study)

Introduction



iv seen
as ii

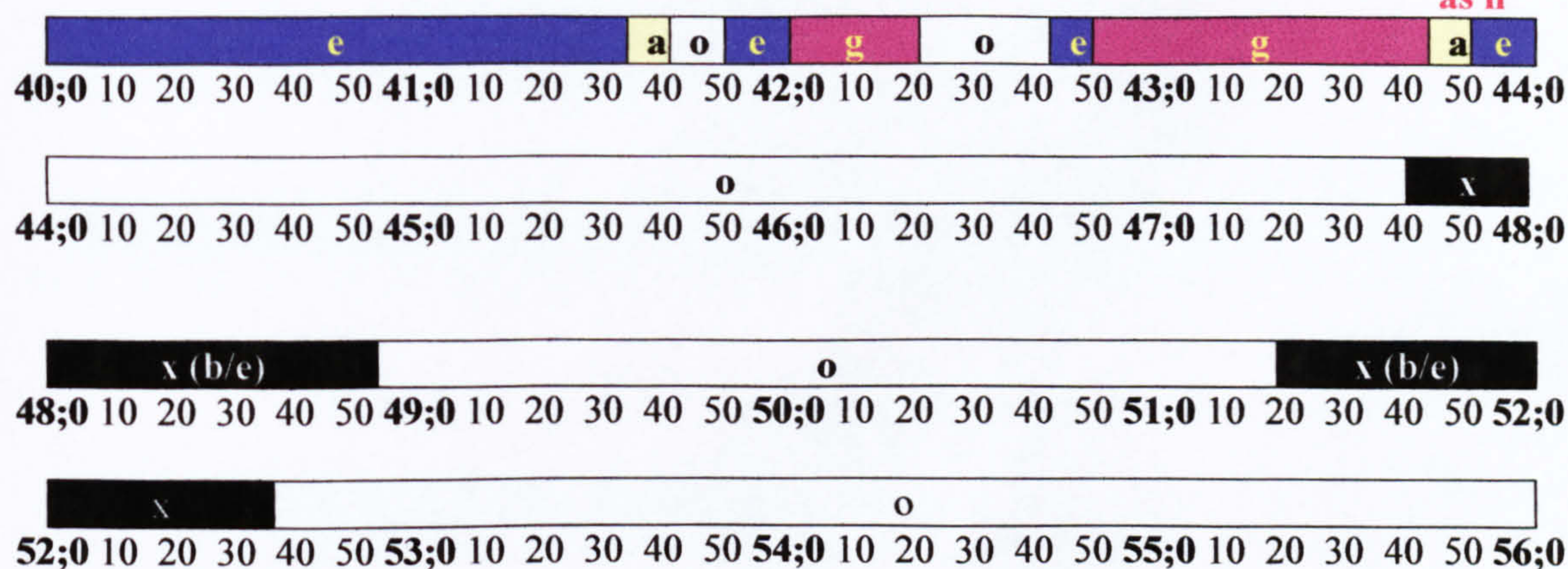
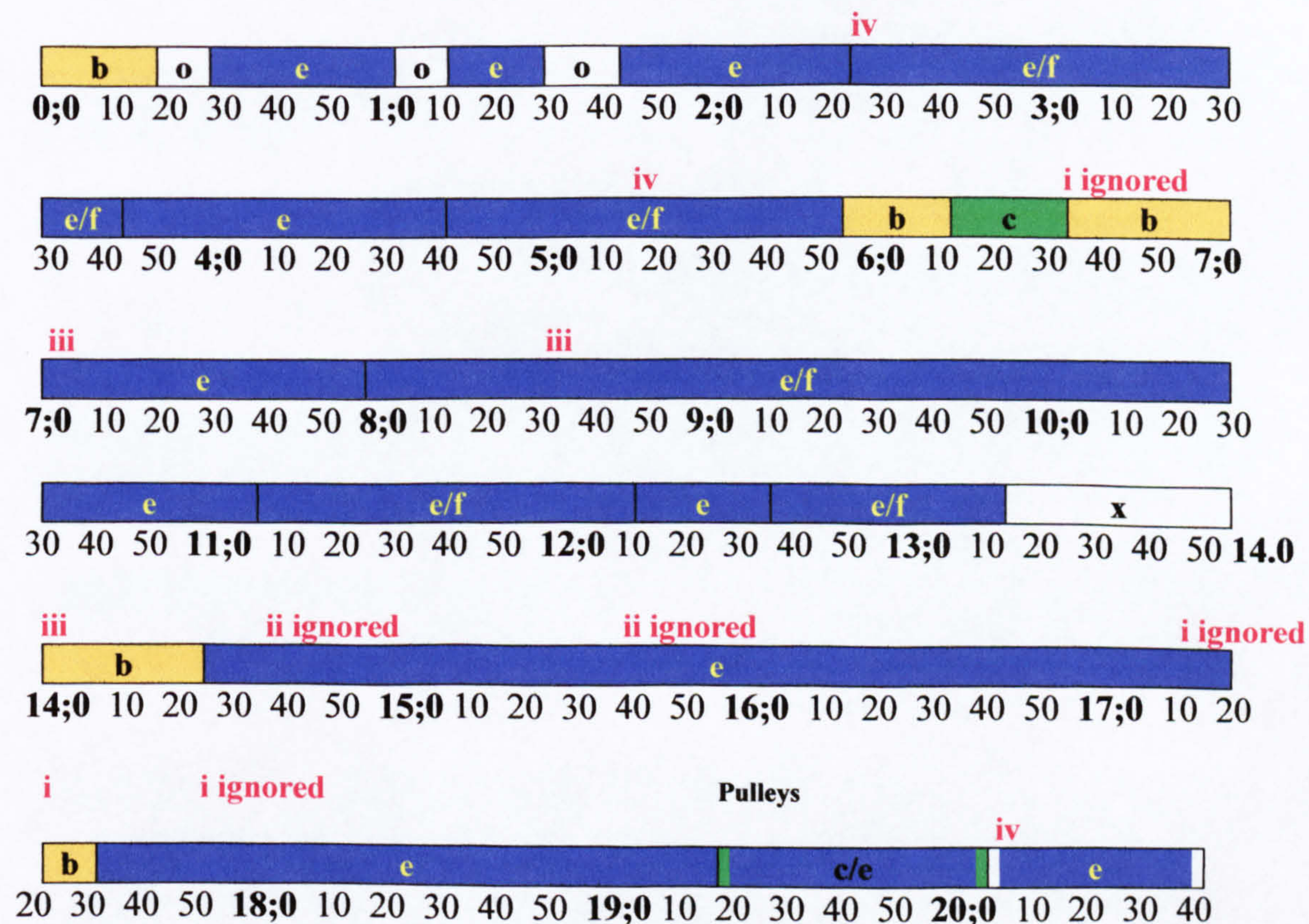


Diagram illustrating the bit positions for the 16-bit register. The register is divided into two 8-bit halves, labeled 'o' (odd) and 'e' (even). The bit positions are numbered from 15 down to 0. The bit positions are labeled as 56;0, 10, 20, 30, 40, 50, and 57;0.

Bill - ISC 2

Gutter



iv e e/f e iv
40 50 21;0 10 20 30 40 50 22;0 10 20 30 40 50 23;0 10 20 30 40 50 24;0

iv e
24;0 10 20 30 40 50 25;0 10 20 30 40 50 26;0 10 20 30 40 50 27;0 10 20

Motion Detector

i iv iii
e e/g e e/f g
20 30 40 50 28;0 10 20 30 40 50 29;0 10 20 30 40 50 30;0 10 20 30 40

Clown

Dominoes

i ignored iii ii ignored
g o e
40 50 31;0 10 20 30 40 50 32;0 10 20 30 40 50 33;0 10 20 30 40 50 34;0

Wind Tunnel

iii iv
c o o e c f/g g
34;0 10 20 30 40 50 35;0 10 20 30 40 50 36;0 10 20 30 40 50 37;0 10 20

g o
20 30 40 50 38;0 10 20 30 40 50 39;0 10 20 30 40 50 40;0 10 20 30 40

Electromagnet

iv ->
o c/g
40 50 41;0 10 20 30 40 50 42;0 10 20 30 40 50 43;0 10 20 30 40 50 44;0

i
c/g c e a e a c/g
44;0 10 20 30 40 50 45;0 10 20 30 40 50 46;0 10 20 30 40 50 47;0 10 20

c d/e e/f a e
20 30 40 50 48;0 10 20 30 40 50 49;0 10 20 30 40 50 50;0 10 20 30 40

i ignored

iii

i e
40 50 51;0 10 20 30 40 50 52;0 10 20 30 40 50 53;0 10 20 30 40 50 54;0

e a e
54;0 10 20 30 40 50 55;0 10 20 30 40 50 56;0 10 20 30 40 50 57;0 10 20

i ignored

e	a	e	e/f	a	e
---	---	---	-----	---	---

20 30 40 50 58;0 10 20 30 40 50 59;0 10 20 30 40 50 60;0 10 20 30 40

i

e

i ignored

i

40 50 61;0 10 20 30 40 50 62;0 10 20 30 40 50 63;0 10 20 30 40

Michael - ISC 1

Introduction

o	a	o	a/b	b	o	b	o	a/b
---	---	---	-----	---	---	---	---	-----

0;0 10 20 30 40 50 1;0 10 20 30 40 50 2;0 10 20 30 40 50 3;0 10 20 30 40 50 4;0

a/b	o
-----	---

4;0 10 20 30 40 50 5;0 10 20 30 40 50 6;0 10 20 30 40 50 7;0 10 20 30 40 50 8;0

Activities

Pulleys

o	e	o
---	---	---

8;0 10 20 30 40 50 9;0 10 20 30 40 50 10;0 10 20 30 40 50 11;0 10 20 30 40 50 12;0

Leg Thump Wave

o	a/c	c	o	c	a/c
---	-----	---	---	---	-----

12;0 10 20 30 40 50 13;0 10 20 30 40 50 14;0 10 20 30 40 50 15;0 10 20 30 40 50 16;0

Magnet

a/c	o	a/c	b	o
-----	---	-----	---	---

16;0 10 20 30 40 50 17;0 10 20 30 40 50 18;0 10 20 30 40 50 19;0 10 20 30 40 50 20;0

Skeleton

o	b	o	a/c	o
---	---	---	-----	---

20;0 10 20 30 40 50 21;0 10 20 30 40 50 22;0 10 20 30 40 50 23;0 10 20 30 40 50 24;0

Pulleys

o	c	b	o	b	o
---	---	---	---	---	---

24;0 10 20 30 40 50 25;0 10 20 30 40 50 26;0 10 20 30 40 50 27;0 10 20 30 40 50 28;0

Skeleton

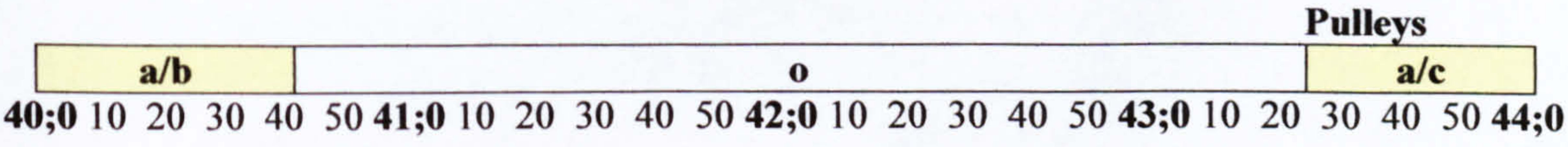
iv stops

o	e	e/f	a/c	c	b	o
---	---	-----	-----	---	---	---

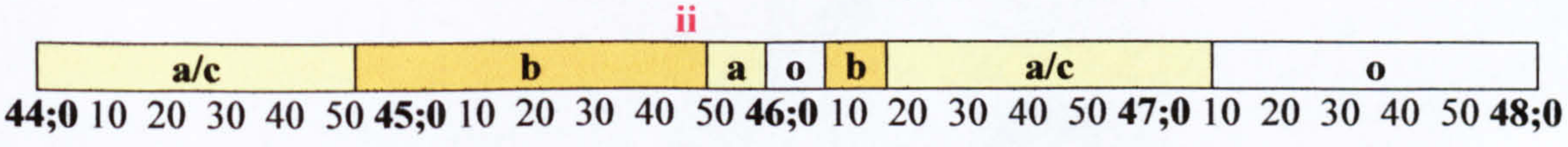
28;0 10 20 30 40 50 29;0 10 20 30 40 50 30;0 10 20 30 40 50 31;0 10 20 30 40 50 32;0

o	g
---	---

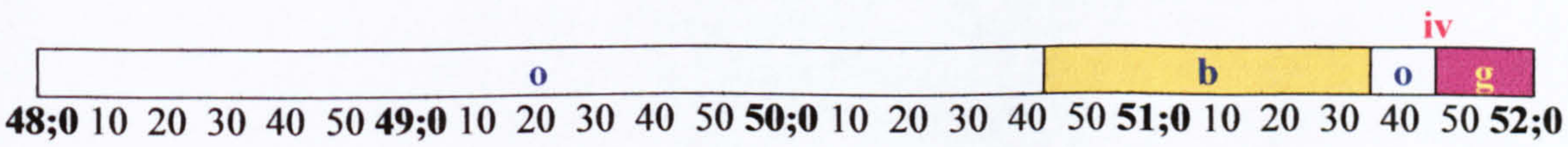
32;0 10 20 30 40 50 33;0 10 20 30 40 50 34;0 10 20 30 40 50 35;0 10 20 30 40 50 36;0



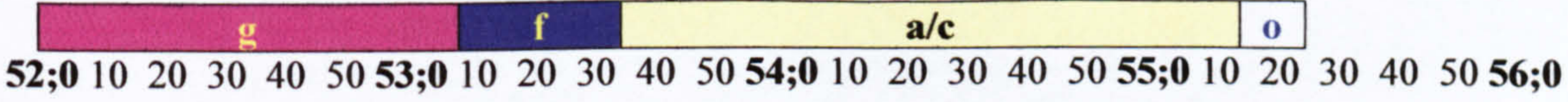
Tilting Gutter
Fish Pulleys



Wind Tunnel

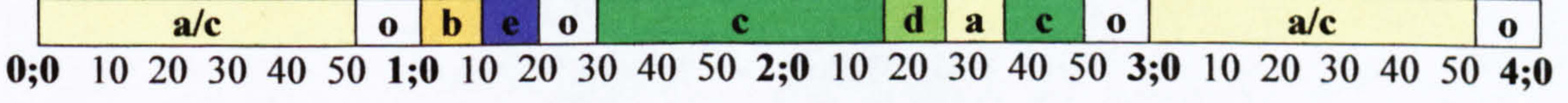


Leg

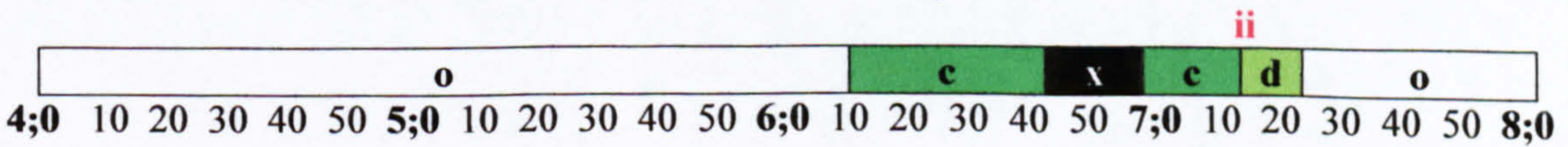


Michael – ISC 2

Leg Wind Tunnel

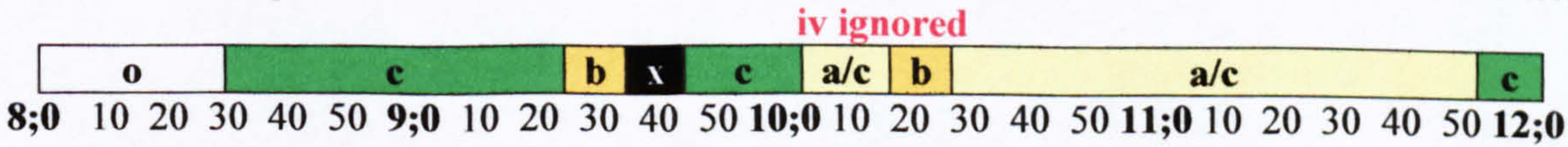


Pulleys



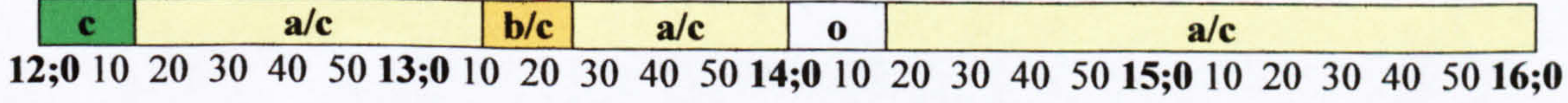
Leg

Skeleton



Leg

iv ignored



iii avoided

a/c	a	x	a/c	b/c	a/c
16;0 10 20 30 40 50 17;0 10 20 30 40 50 18;0 10 20 30 40 50 19;0 10 20 30 40 50 20;0					

ii resisted

a/c	x	b	a/c	o	a/c
20;0 10 20 30 40 50 21;0 10 20 30 40 50 22;0 10 20 30 40 50 23;0 10 20 30 40 50 24;0					

iii ignored
ii resisted
i + ii resisted

a/c	a	x	o	a/c	o
24;0 10 20 30 40 50 25;0 10 20 30 40 50 26;0 10 20 30 40 50 27;0 10 20 30 40 50 28;0					

Thump Wave Skeleton

Thump Wave

ii resisted
i resisted **ii** **ii**

a/c	a	a/c	b	a/c	a	b	o	b	a
28;0 10 20 30 40 50 29;0 10 20 30 40 50 30;0 10 20 30 40 50 31;0 10 20 30 40 50 32;0									

Skeleton **Leg**

b	x	b	o	b/e	o	c
32;0 10 20 30 40 50 33;0 10 20 30 40 50 34;0 10 20 30 40 50 35;0 10 20 30 40 50 36;0						

Dominoes **Leg**

c	b	c	a	c
36;0 10 20 30 40 50 37;0 10 20 30 40 50 38;0 10 20 30 40 50 39;0 10 20 30 40 50 40;0				

Magnet

Pulleys

ii **iv**

c	o	a/c	b	o	b	o	a/b	o	a/b
40;0 10 20 30 40 50 41;0 10 20 30 40 50 42;0 10 20 30 40 50 43;0 10 20 30 40 50 44;0									

APPENDIX VII: SAMPLE OF FIELD NOTES

[redacted] [redacted] - Play Session

M [redacted] - clown with floppy hat -
rocking, finger in mouth.

→ floor by rail track - watching
[redacted] O [redacted] play. Twiddling legs

J [redacted] - blocks - building tower -
on own but responsive to others.
esp adult - accepted other child
knocking down

A [redacted] playdo - alone, silent -
v. concentrated - responded to Pleased
with sausage

J. trying to join in with train
with Oliver - smiling - some interaction

M - twiddling stickle bricks - offered
to [redacted] Teacher she said 'just one' - M gave h
Lay on chair for a while - refused
to a computer - later

A: "All gone" (playdo)

J: painting on computer - "I like
that" then → sand - poured sand into
sandwheel - only stayed 30 sec.
2 mins with train then → playdo

M remained 15 mins at computer (touch vehicles + so)
- moved away → music - listening

J. longer attention at playdo - making
different shapes/patterns

APPENDIX VIII: PUBLISHED WORK ASSOCIATED WITH THIS THESIS

Brooke, H. and Solomon, J. (1996) Hands-on, brains-on: playing and learning in an Interactive Science Centre, *Primary Science Review*, 44, 14-16.

Brooke, H. and Solomon, J. (1998) From playing to investigating: research in an Interactive Science Centre for primary pupils, *International Journal of Science Education*, 20(8), 959-971.

Brooke, H. and Solomon, J. (2001) Passive visitors or independent explorers: responses of pupils with severe learning difficulties at an Interactive Science Centre, *International Journal of Science Education*, 23 (9), 941-953.

Brooke, H. and Solomon, J. (2003) Children in an Interactive Science Centre, in Solomon, J. (ed.) *The Passion to Learn: An Inquiry into Autodidactism*. London: RoutledgeFalmer.

Dissertation

Brooke, H. (1994) *Playing and Learning in an Interactive Science Centre: A Study of Primary School Children*. Unpublished dissertation for the University of Oxford Department of Educational Studies Special Diploma In Educational Studies.

Conference paper

Brooke, H. (2004) *Responses of Students with Severe Learning Difficulties to the Educational Environment Provided by a Small Interactive Science Centre*. Presentation to the British Educational Research Association New Researchers/Student Conference at UMIST, Manchester.